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PRS GLOBAL OPEN

ORIGINAL ARTICLE

Hand

Selection Bias in Avoiding Vein Graft in Replantation/Revascularization May Exist in Distal and Proximal Amputations, Respectively

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Background: No difference in the success rate has been reported between the vein graft and non–vein graft groups in replantation/revascularization. However, this depends on a wide range of indications in difficult cases. This study aimed to investigate the selection bias in avoiding vein grafts.

Methods: This is a single-center, noninterventional, retrospective cohort study comprising 229 patients (277 digits) who underwent replantation/revascularization between January 2000 and December 2020 at our institution. Sex, age, smoking history, comorbidities, affected side, level of amputation, complete or incomplete amputation, type of fracture and mechanism, diameter of the artery, needle, warm ischemic time, and results were investigated and compared between the subgroups with and without vein graft. Results were investigated between the subgroups with and without a vein graft in the distal and proximal groups.

Results: In the distal group, the mean arterial diameter of the vein graft subgroup was larger than that of the non–vein graft subgroup [0.7 (0.1) mm and 0.6 (0.2) mm, respectively, $P < 0.05$]. In the proximal group, the vein graft subgroup had higher severity than the non–vein graft subgroup (comminuted fracture, 31.1% versus 13.4%; and avulsion or crush amputation, 57.8% versus 37.1%, respectively, $P < 0.05$). However, the success rate was not significantly different between the aforementioned subgroups.

Conclusion: There was no significant difference between the vein graft and non–vein graft subgroups owing to the selection bias avoiding small arteries in the distal amputation and the absence of said bias in the proximal amputation. *(Plast Reconstr Surg Glob Open 2023; 11:e4992; doi: 10.1097/GOX.0000000000004992; Published online 24 May 2023.)*

INTRODUCTION

The integrity of the digital vessels is critical for successful microvascular anastomosis. The success rate of replantation/revascularization varies between studies and depends on the surgeon's technique and wide-ranging indications in difficult cases.[1–5] A vein graft is more readily used in crush and avulsion amputations compared with guillotine amputations.[6] According to recent reports, there is no difference in the success rate between vein graft and non–vein graft groups.[4–9]

However, the same concern may occur in replantation/revascularization using the vein graft. The success rate of replantation/revascularization using interpositional vein graft may also depend on the surgeon's technique and various indications; in addition, there may be a selection bias in avoiding a vein graft.[7]

Former reports solely focused on the replantation/revascularization of the fingertips or did not consider different aspects between the amputation of fingertips and proximal fingers.[4–9] We divided the cohort into the fingertip and proximal finger groups and investigated each group separately. This study aimed to investigate the occurrence of selection bias in performing a vein graft in the distal and proximal amputations, as well as whether said selection bias affects the success rate.

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Received for publication November 22, 2022; accepted March 20, 2023.

DOI: 10.1097/GOX.0000000000004992

Disclosure statements are at the end of this article, following the correspondence information.

METHODS

This single-center, noninterventional, retrospective cohort study was conducted in a general hospital between January 2000 and December 2020, comprising 229 patients (277 digits) who visited our emergency room and underwent replantation/revascularization. Institutional review board approval was obtained, and each patient provided informed consent (Fig. 1).

All patient records from operative reports, inpatient stay, and outpatient visits were collected. The following variables were collected: sex; age; comorbidities; active smoking; affected side and digit; aspects of amputation (Tamai zone, complete or incomplete and single or multiple);[10] type of fracture (none or simple/comminuted), mechanism (guillotine, avulsion, or crush); diameter of the artery (smaller diameter was used in case of a discrepancy); needle type (10-0, 11-0, or 12-0; smaller needles were used in case of using more than two different needles); artery-only replantation; warm ischemic time; and result (survival/necrotic).

Patients who stopped smoking more than one month preoperatively were not defined as active smokers. Comorbidities included diabetes mellitus, autoimmune diseases, and vascular disorders (cerebral infarction, myocardial infarction, and arterial sclerotic occlusion). The zone was determined by the level of the arterial anastomosis, or by the distal arterial anastomosis in the case of using a vein graft. Incomplete amputation was defined as amputation with a skin bridge more than 5 mm without vascular circulation.

A comminuted fracture was defined as a fracture including not only the edge but also the diaphyseal comminution. The mechanism of injury was classified as a guillotine, avulsion, or crush amputation. Crush amputation excluded mutilated fingers or multiple-level amputation.

The diameter of the artery was measured using a background sheet with a printed scale (Supermicrosheet: Crownjun, Tokyo, Japan) under a microscope with high magnification (MM50/YOH: Mitaka Kohki, Tokyo, Japan). The outer diameter of the artery on the sheet

Takeaways

Question: Would there be a possibility of selection bias for avoiding vein graft in replantation/revascularization?

Findings: In the distal amputation group, the arterial diameter was larger in the vein graft subgroup. In the proximal group, severity of the amputation was similar, regardless of applying vein graft. No difference in the success rate was found in either group.

Meaning: No difference in success rate was attributed to the selection bias in distal amputation, and there was no selection bias in proximal amputation.

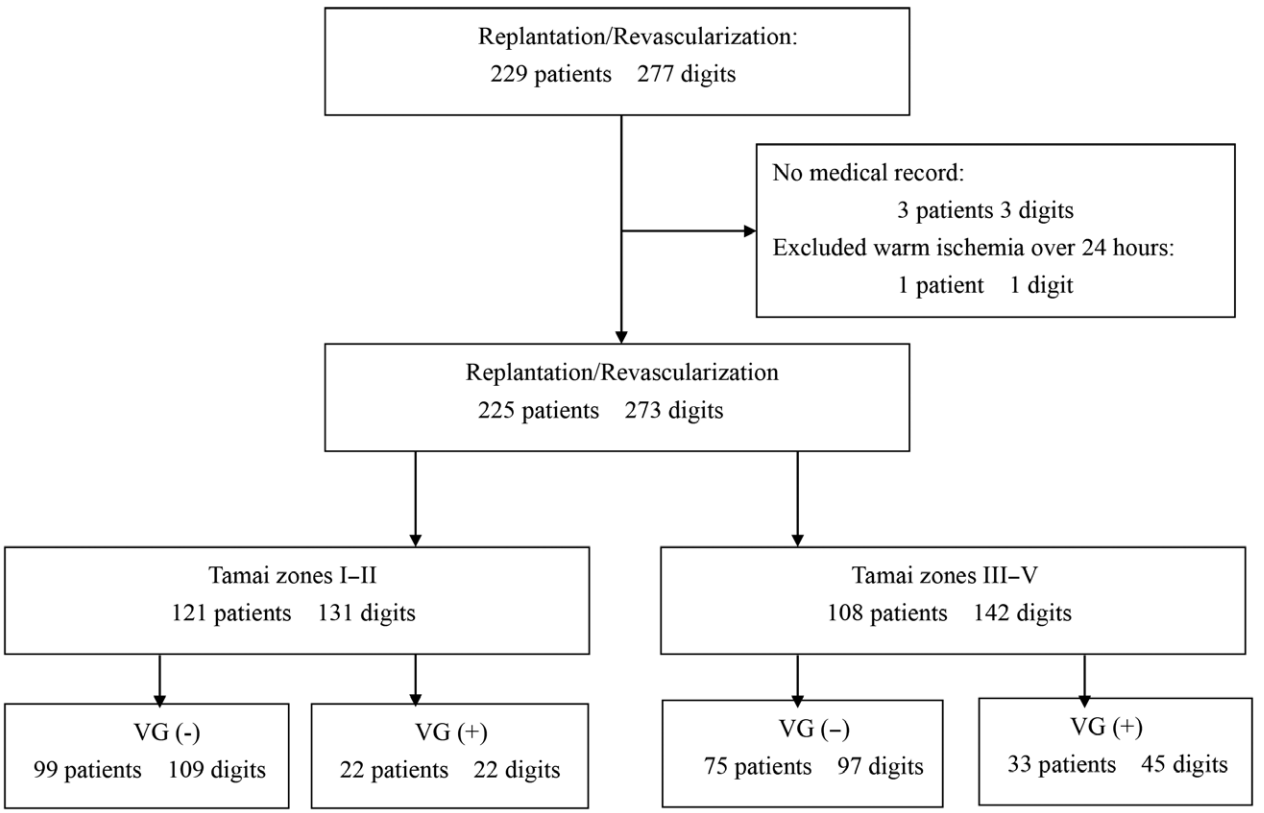

Fig. 1. Flowchart of study participation. Amputations were divided into Tamai zones I and II (distal amputation group) and Tamai zones III, IV, and V (proximal amputation groups). Moreover, the groups were further divided into the vein graft (VG+) and non–vein graft (VG-) subgroups.

was recorded before dilatation under a magnification of 50× by video. The researchers reviewed the video and measured the diameter before dilatation on the monitor. The diameter was subsequently determined through a consensus decision. Atrophic fingers were included in the survival group, and fingers with an unexpected return to the operative room were included in the necrotic group.

The mode of anesthesia was general anesthesia or axillary nerve block. The tourniquet was set at an additional 80 mm Hg to the blood pressure (minimum 200 mm Hg). Twenty millimeters of an axillary nerve block (7.5 mg of ropivacaine) was used for anesthesia.

Six surgeons were involved in the surgical procedures. All surgeons were able to anastomose a practice silicon tube of 0.3 mm in diameter using a 12-0 needle within 20 min. The order of surgery was as follows: bone fixation, tendon suture, nerve suture, arterial anastomosis, and venous anastomosis. Our strategy of replantation/revascularization was to perform the surgery in case of identification of the artery in accordance with the patient's preferences. In the case of finger replantation, we attempted to anastomose the arteries, although the diameter was less than 0.5 mm. Furthermore, even in severe cases, we also attempted to perform surgery if we were able to identify the artery, regardless of the possibility of success or function. The vein graft was harvested from the distal volar forearm or palmar side of the thenar eminence of the hand. The application of the interpositional vein graft was decided by each surgeon depending on the situation. Patients with a warm ischemia time more than 24 hours were excluded.[11]

Upon completion of the digital artery anastomosis, 2000 units of unfractionated heparin were administered intravenously, followed by 10,000 unit of unfractionated heparin daily for 1 week and prostaglandin E1 (20 μg) for 3 days intravenously. Patients were on complete bed rest for 1 week. There was no remarkable change in surgical procedures or postoperative protocols between 2000 and 2020.

We divided the cohort into the distal (Tamai zones I and II) and proximal (Tamai zones III, IV, and V) amputation groups. We first evaluated differences in variables between the distal and proximal groups to determine the variables that might have caused the selection biases in avoiding a vein graft. Subsequently, we compared the variables between the vein and non–vein graft subgroups in the distal and proximal amputation groups.

Categorical variables were evaluated using frequency and compared using the Fisher exact test. Continuous parameters were expressed as mean and standard deviation, as well as compared using the Mann-Whitney *U* test. Univariate analysis of each variable was conducted before including the said variable in the multivariable logistic regression analysis. Dependent variables in multivariable logistic regression were distal amputation and proximal amputation between the groups of distal and proximal analysis, as well as vein graft and non–vein graft between the subgroups of replantation/revascularization with and without vein graft. A *P* value less than 0.05 was considered statistically significant for all variables. Results were presented as odds ratios with 95% confidence intervals (CI). All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan).[12]

RESULTS

There was no statistically significant difference regarding the survival rate and vein graft applying rate. The survival rate of replantation/revascularization between 2000 and 2010, as well as 2011 and 2022, was 94 of 113 digits (83.2%) and 133 of 160 digits (83.1%), respectively (95% CI, 0.50–2.03; $P = 1.0$). The ratio of applying the vein graft was 30 of 113 digits (26.5%) and 37 of 160 digits (23.1%), respectively (95% CI, 0.66–2.17; $P = 0.57$).

The rate of applying vein graft in each Tamai zone I to V was 11.9%, 22.5%, 24.1%, 28.6%, and 50%, respectively. The success rate in each Tamai zone was 86.6%, 85.5%, 5.9%, 87.5%, and 75%, respectively.

Tables 1 and 2 present the results of the univariate and multivariable analyses between the distal (Tamai zones I and II) and proximal (Tamai zone III, IV, and V) amputation groups. Univariate analysis showed that there were more men, complete amputations, and single-digit amputations in the distal amputation group than in the proximal amputation group ($P < 0.05$). There were also more single-digit amputations, particularly in Tamai zone I [64 digits (95.5%; $P < 0.05$)]. Moreover, the arterial diameter and needles were smaller, and there was more artery-only replantation ($P < 0.05$).

In contrast, in the proximal amputation group, there were more multiple-digit amputations ($P < 0.05$), particularly 19 digits (63.3%) in Tamai zone V ($P < 0.05$). Moreover, there were more comminuted fracture and avulsion/crush amputations, more vein grafts, and longer warm ischemic time ($P < 0.05$). However, there was no statistical difference in age, comorbidity, active smoking, affected side and digit, or the success rate between groups (Table 1).

In multivariable logistic regression analysis, to adjust each variable, we selected age, comorbidity, and active smoking as corrective variables, which showed no statistically significant difference in univariate analysis and more possibly affected the survival rate. The variables that showed statistically significant differences in univariate analysis were adjusted by the corrective variables, yet they still showed statistically significant differences in the multivariable analysis, except for gender. The variables that showed no statistically significant differences in univariate analysis still did not demonstrate any noticeable difference in multivariable analysis (Table 2).

Table 3 presents the difference between the non–vein graft and vein graft subgroups in the distal amputation group. Univariate analyses revealed that there were more incomplete amputations and a larger arterial diameter in the vein graft subgroup than in the non–vein graft subgroup [0.7 (0.1) mm and 0.6 (0.2) mm, respectively, $P < 0.05$]. We found no statistically significant differences except in these variables.

Table 1. Univariate Associations between Outcome of Replantations/Revascularizations of Distal Fingers and Proximal Fingers

Variable	Tamai Zones I–II (Patient = 121; Digit = 131)	Tamai Zones III, IV, and V (Patient = 108; Digit = 142)	Results of Univariate Analysis	
			P	95% CI
Gender, male/female (%)	101 (83.5)/20 (16.5)	100 (92.6)/8 (7.4)	*P* = 0.04	0.15–1.02
Age, y (mean [SD])	45.1 (17.1)	48.7 (17.1)	*P* = 0.124	
Comorbidity (yes/no) (%)	5 (4.1)/116 (95.9)	10 (9.3)/98 (90.7)	*P* = 0.18	0.11–1.42
Active smoking (yes/no) (%)	36 (29.8)/85 (70.2)	43 (39.8)/65 (60.2)	*P* = 0.13	0.36–1.15
Side (right/left) (%)	55 (45.5)/66 (54.5)	52 (48.1)/56 (51.9)	*P* = 0.69	0.52–1.56
Digit (T/I/M/R/L) (%)	26 (19.8)/29 (22.1)/35 (26.7)/24 (18.4)/17 (13.0)	17 (12.0)/45 (31.7)/39 (27.5)/26 (18.2)/15 (10.6)	*P* = 0.257	
Complete/incomplete (%)	95 (72.5)/36 (27.5)	66 (46.5)/76 (53.5)	*P* = 2e-5	1.78–5.21
Single/multiple (%)	110 (86.0)/21 (16.0)	74 (52.1)/68 (47.9)	*P* = 2e-8	2.64–8.96
Fracture (none or simple/comminuted) (%)	125 (95.4)/6 (4.6)	115 (81.0)/27 (19.0)	*P* = 3e-4	1.88–19.95
Mechanism (guillotine/avulsion or crush) (%)	96 (73.3)/35 (26.7)	80 (56.3)/62 (43.7)	*P* = 4e-3	1.24–3.66
Diameter of the artery (mm) (mean [SD])	0.6 (0.2)	0.9 (0.2)	*P* = 9e-23	
Needle (10/11 or 12) (%)	31 (23.7)/100 (76.3)	112 (78.9)/30 (21.1)	*P* = 1e-20	0.05–1.15
Artery-only* (yes/no) (%)	31 (32.6)/64 (67.4)	5 (7.6)/61 (92.4)	*P* = 2e-4	2.07–20.54
Vein graft (yes/no)	22 (16.8)/109 (83.2)	45 (31.7)/97 (68.3)	*P* = 5e-3	0.23–0.80
Warm ischemic time (mean [SD])	465.1 (136.9)	507.6 (134.9)	*P* = 5e-3	
Success/necrosis (%)	113 (86.3)/18 (13.7)	114 (80.3)/28 (19.7)	*P* = 0.20	0.77–3.14

*Only complete amputation.
T, thumb; I, index finger; M, middle finger; R, ring finger; L, little finger; complete, complete amputation; incomplete, incomplete amputation; single, single-digit amputation; multiple, multiple-digit amputation; none, no fracture; simple, simple fracture; comminuted, comminuted fracture; guillotine, guillotine amputation; avulsion, avulsion amputation; crush, crush amputation; needle, needle type; 10, 10-0 needle; 11, 11-0 needle; 12, 12-0 needle; artery-only, artery-only replantation.

Table 2. Multivariable Associations between Outcome of Replantations/Revascularizations of Distal Fingers and Proximal Fingers

Variable	Results of Multivariable Analysis	
	P	OR (95% CI)
Gender, male/female	*P* = 0.08	0.45 (0.19–1.09)
Side, right/left	*P* = 0.86	0.95 (0.56–1.62)
Complete/incomplete	*P* = 4e-6	0.27 (0.15–0.469)
Single/multiple	*P* = 7e-5	4.78 (2.64–8.963)
Fracture (none or simple/comminuted)	*P* = 2s-3	4.52 (1.73–11.80)
Mechanism (guillotine/avulsion or crush)	*P* = 0.049	1.77 (1.00–3.11)
Diameter of the artery	*P* = 3e-13	507.0 (94.60–2720.00)
Needle (10/11 or 12)	*P* = 8e-13	0.07 (0.04–1.14)
Artery-only* (yes/no)	*P* = 9e-8	0.06 (0.02–0.16)
Vein graft (yes/no)	*P* = 0.03	1.98 (1.06–3.70)
Warm ischemic time	*P* = 0.02	1.0 (1.00-1.00)
Success/necrosis	*P* = 0.27	1.50 (0.73–3.05)

*Only complete amputation.
OR, odds ratio; complete, complete amputation; incomplete, incomplete amputation; single, single-digit amputation; multiple, multiple-digit amputation; fracture, type of the fracture; none, no fracture; simple, simple fracture; comminuted, comminuted fracture; guillotine, guillotine amputation; avulsion, avulsion amputation; crush, crush amputation; needle, needle type; 10, 10-0 needle; 11, 11-0 needle; 12, 12-0 needle; artery-only, artery-only replantation.

In multivariable logistic regression analyses, to adjust each variable, we selected mechanism as a corrective variable, which showed no statistically significant difference in univariate analysis and more possibly affected the survival rate. The variables that showed statistically significant differences in univariate analysis still showed statistically significant differences in multivariable analysis, and the same was true for the variables that did not (Table 4).

Table 5 presents the difference between the non–vein graft and vein graft subgroups in the proximal amputation group. Univariate analyses revealed no statistically significant differences in sex, age, comorbidities, active smoking, affected side, digits, single/multiple amputation, diameter, or artery-only replantation. However, there were more incomplete amputations, comminuted fractures, avulsion or crush amputations, longer warm ischemic time, and fewer survived digits in the vein graft subgroup than in the non–vein graft subgroup (comminuted fracture, 31.1% and 13.4%; avulsion or crush amputation, 57.8% and 37.1%, respectively, $P < 0.05$).

In multivariable logistic regression analyses, to adjust each variable, we selected arterial diameter, needle, and frequency of multiple digit amputation, as corrective variables, which showed no statistically significant differences in univariate analysis and more possibly affected survival rate. The variables that showed statistically significant differences in univariate analysis still showed statistically significant differences in multivariable analysis, except for warm ischemic time and survival rate ($P = 0.06$, respectively). The same was true for the variables that did not show any statistically significant difference in univariate analysis (Table 6).

DISCUSSION

In the 1990s, microvascular vein grafting for digital replantation has been noted to increase the risk of vessel

Table 3. Univariate Associations between Outcome of Replantations/Revascularizations of Distal Fingers with and without Vein Graft

Variable	Non-VG Group (Patient = 99; Digit = 109)	VG Group (Patient = 22; Digit = 22)	Results of Univariate Analysis	
			P	95% CI
Gender (male/female) (%)	83 (83.8)/16 (16.2)	18 (81.8)/4 (18.2)	*P* = 0.76	0.25–4.18
Age, y (mean [SD])	44.6 (17.1)	47.4 (17.0)	*P* = 0.51	
Comorbidity (yes/no) (%)	5 (5.1)/94 (94.9)	0 (0)/22(100)	*P* = 0.58	0.20–inf
Active smoking (yes/no) (%)	32 (32.3)/67 (67.7)	4 (18.2)/18 (81.8)	*P* = 0.30	0.63–9.31
Side (right/left) (%)	42 (42.4)/57 (57.6)	13 (59.1)/9 (40.9)	*P* = 0.16	0.17–1.41
Digit (T/I/M/R/L) (%)	20 (18.3)/27 (24.8)/28 (25.7)/19 (17.4)/15 (13.8)	6 (27.3)/2 (9.1)/7 (31.8)/5 (22.7)/2 (9.1)	*P* = 0.44	
Complete/incomplete (%)	84 (77.1)/25 (22.9)	11 (50.0)/11 (50.0)	*P* = 0.02	1.16–9.62
Single/multiple (%)	91 (83.5)/18 (16.5)	19 (86.4)/3 (13.6)	*P* = 1	0.14–3.17
Fracture (none or simple/comminuted) (%)	106 (92.7)/3 (2.7)	19 (86.4)/3 (13.6)	*P* = 0.06	0.68–43.01
Mechanism (guillotine/avulsion or crush) (%)	82 (75.2)/27 (24.8)	14 (63.6)/8 (36.4)	*P* = 0.29	0.56–5.00
Diameter of the artery (mm) (mean [SD])	0.6 (0.2)	0.7 (0.1)	*P* = 7e-3	
Needle (10/11 or 12) (%)	26 (23.9)/83 (76.1)	5 (22.7)/17 (77.3)	*P* = 1	0.33–4.05
Artery-only* (yes/no) (%)	26 (32.5)/58 (69.0)*	5 (45.5)/6 (54.5)*	*P* = 0.33	0.12–2.46
Warm ischemic time (mean [SD])	469.7(136.1)	442.0 (138.0)	*P* = 0.37	
Success/necrosis (%)	96 (88.1)/13 (11.9)	17 (77.3)/5 (22.7)	*P* = 0.19	0.53–7.58

*Only complete amputation.
Non-VG, replantations/revascularizations without vein graft; VG, replantations/revascularizations with vein graft; T, thumb; I, index finger; M, middle finger; R, ring finger; L, little finger; complete, complete amputation; incomplete, incomplete amputation; single, single-digit amputation; multiple, multiple-digit amputation; none, no fracture; simple, simple fracture; comminuted, comminuted fracture; guillotine, guillotine amputation; avulsion, avulsion amputation; crush, crush amputation; needle, needle type; 10, 10-0 needle; 11, 11-0 needle; 12, 12-0 needle; artery-only, artery-only replantation.

Table 4. Multivariable Associations between Outcome of Replantations/Revascularizations of Distal Fingers with and without Vein Graft

Variable	Results of Multivariable Analysis	
	P	OR (95% CI)
Gender (male/female)	*P* = 0.88	1.10 (0.32–3.71)
Age, y	*P* = 0.55	1.01 (0.98–1.04)
Comorbidity (yes/no)	*P* = 0.99	0.00 (0.00–inf)
Active smoking (yes/no)	*P* = 0.19	0.46 (0.14–1.48)
Side (right/left)	*P* = 0.20	0.54 (0.21–1.40)
Complete/incomplete	*P* = 4e-3	0.20 (0.07–0.60)
Single/multiple	*P* = 0.59	0.69 (0.18–2.67)
Fracture (none or simple/comminuted)	*P* = 0.51	2.28 (0.20–25.70)
Diameter of the artery	*P* = 0.01	22.6 (2.13–239.00)
Needle (10/11 or 12)	*P* = 0.96	1.03 (0.344–3.08)
Artery-only*	*P* = 0.38	0.56 (0.155–2.040)
Warm ischemic time	*P* = 0.32	1.00 (0.995–1.00)
Success/necrosis	*P* = 0.28	1.93 (0.581–6,420)

*Only complete amputation.
OR, odds ratio; complete, complete amputation; incomplete, incomplete amputation; single, single-digit amputation; multiple, multiple-digit amputation; none, no fracture; simple, simple fracture; comminuted, comminuted fracture; needle, needle type; 10, 10-0 needle; 11, 11-0 needle; 12, 12-0 needle; artery-only, artery-only replantation.

occlusion in animal experiments. Vein grafting with two anastomoses doubles the possibility of technical failure and thrombogenic response to vessel trauma, possibly promoting flow disturbances and subsequent thrombus formation.[13–16] It is imperative that an adequate resection of injured vessels is performed, which may require an interpositional graft to bridge the gap. Recent studies have suggested that the success rate is similar between replantation/revascularization with and without vein graft.[4–9] However, the success rate of replantation/revascularization using interpositional vein graft may be improved if difficult cases are avoided.

In distal finger replantation/revascularization, there was no statistically significant difference in success rate between the non–vein graft and vein graft subgroups. However, the characteristics of distal finger amputation in this study were the use of arteries with a smaller diameter and smaller needle in the vein graft subgroup. We assumed that these variables may induce a selection bias in the distal group.

Our strategy of replantation/revascularization for fingertip amputation was to perform the surgery if we were able to identify the artery. Nevertheless, we applied smaller amounts of vein graft to smaller arteries, although we tried to anastomose the vessels using the same small needles used in the non–vein graft group. We might have converted to simple stump revision instead of applying vein graft in such cases. Sebastin et al reported that interposing a vein graft to small vessels in the fingertip is a difficult maneuver.[7] Applying more vein graft to the smaller arteries might have decreased the success rate in the vein graft subgroup. Therefore, these results suggest that our study might have had a selection bias in not applying vein grafts in the smaller arteries, even though this was unintentional.

Moreover, we assumed that more frequently, the arteries of the distal stumps were too damaged or too short to be identified, secured, or anastomosed in severe cases

Table 5. Univariate Associations between Outcome of Replantations/Revascularizations of Proximal Fingers with and without Vein Graft

Variable	Non-VG Group (Patient = 75; Digit = 97)	VG Group (Patient = 33; Digit = 45)	Results of Univariate Analysis	
			P	95% CI
Sex (male/female) (%)	71 (94.7)/4 (5.3)	29 (87.9)/4 (12.1)	*P* = 0.24	0.42–13.97
Age, year (mean [SD])	48.3 (17.7)	49.5 (15.5)	*P* = 0.77	
Comorbidity (yes/no) (%)	5 (6.7)/70 (93.3)	5 (15.2)/28 (84.8)	*P* = 0.17	0.09–1.90
Active smoking (yes/no) (%)	30 (40.0)/45 (60.0)	13 (39.4)/20 (60.6)	*P* = 1	0.41–2.61
Side (right/left) (%)	33 (44.0)/42 (56.0)	19 (57.6)/14/ 42.4)	*P* = 0.22	0.23–1.43
Digit (T/I/M/R/L) (%)	13 (13.4)/27 (27.9)/26 (26.8)/20 (20.6)/11 (11.3)	4 (8.9)/18 (40.0)/13 (28.9)/6 (13.3)/4 (8.9)	*P* = 0.59	
Complete/incomplete (%)	57 (58.8)/40 (41.2)	9 (20.0)/36 (80.0)	*P* = 2e-5	2.34–14.82
Single/multiple (%)	58 (57.6)/42 (42.4)	26 (57.8)/19 (42.2)	*P* = 1	0.46–2.18
Fracture (none or simple/comminuted) (%)	84 (86.6)/13 (13.4)	31 (68.9)/14 (31.1)	*P* = 0.02	1.12–7.54
Mechanism (guillotine/avulsion or crush) (%)	61 (62.9)/36 (37.1)	19 (42.2)/26 (57.8)	*P* = 0.03	1.06–5.09
Diameter of the artery (mm) (mean [SD])	0.9 (0.1)	0.9 (0.2)	*P* = 0.87	
Needle (10/11 or 12) (%)	80 (82.5)/17 (17.5)	32 (71.1)/13 (28.9)	*P* = 0.13	0.76–4.72
Artery-only* (yes/no) (%)	5 (8.8)/52 (91.2)	0 (0)/9 (100)	*P* = 1	0.135–inf
Warm ischemic time (mean [SD])	490.2 (130.7)	545.0 (136.2)	*P* = 0.01	
Success/necrosis (%)	83 (85.6)/13 (14.4)	31 (68.9)/14 (31.1)	*P* = 0.02	1.11–7.45

*Only complete amputation.

non-VG, replantations/revascularizations without vein graft; VG, replantations/revascularizations with vein graft; T, thumb; I, index finger; M, middle finger; R, ring finger; L, little finger; complete, complete amputation; incomplete, incomplete amputation; single, single-digit amputation; multiple, multiple-digit amputation; none, no fracture; simple, simple fracture; comminuted, comminuted fracture; guillotine, guillotine amputation; avulsion, avulsion amputation; crush, crush amputation; needle, needle type; 10, 10-0 needle; 11, 11-0 needle; 12, 12-0 needle; artery-only, artery-only replantation.

TABLE 6. Multivariable Associations between Outcome of Replantations/Revascularizations of Proximal Fingers with and without Vein Graft

Variable	Results of Multivariable Analysis	
	P	OR (95% CI)
Gender (male/female)	*P* = 0.19	2.73 (0.60–12.40)
Age, y	*P* = 0.76	1.0 (0.98–1.03)
Comorbidity	*P* = 0.23	2.32 (0.59–9.07)
Active smoking	*P* = 0.90	0.95 (0.40–2.22)
Side (right/left)	*P* = 0.27	0.62 (0.27–1.45)
Complete/incomplete	*P* = 1e-6	0.04 (0.01–0.15)
Fracture (none or simple/comminuted)	*P* = 0.02	2.85 (1.18–6.85)
Mechanism (guillotine/avulsion or crush)	*P* = 0.03	2.29 (1.08–4.89)
Artery-only*	*P* = 0.99	0.00 (0.00–inf)
Warm ischemic time	*P* = 0.06	1.0 (1.00–1.01)
Success/necrosis	*P* = 0.06	2.76 (0.96–7.93)

*Only complete amputation.

OR, odds ratio; CI, confidence interval; complete, complete amputation; incomplete, incomplete amputation; none, no fracture; simple, simple fracture; comminuted, comminuted fracture; guillotine, guillotine amputation; avulsion, avulsion amputation; crush, crush amputation;artery-only, artery-only replantation.

in the distal group, regardless of whether a vein graft was applied. The severity in the distal amputation group was "nonindication" rather than "avoiding bias." Therefore, the variables regarding severity might not cause bias in avoiding vein graft in the distal amputation group.

In contrast, the characteristics of the proximal finger amputation group more frequently were multiple amputations, comminuted fractures, and avulsed or crushed amputations. The possible selection bias in the proximal group would be due to multiple amputations and the severity of injuries. However, these variables decreased the effects of selection bias in avoiding a vein graft, because there were more vein grafts in severe cases and no statistically significant difference in terms of multiple amputations. Nevertheless, there was no statistically significant difference in the success rate of the subgroups with and without vein grafts in the proximal amputation group.

In replantation/revascularization, the vessels may still have injured intima after resection because confirming whether the intima is intact from appearance is sometimes difficult. Moreover, even if the intima is intact, damage to the soft tissue may affect the circulation in cases of avulsed or crushed amputation.[13–16]

Lee et al reported that there was no difference in the success rate between the groups with and without vein grafts.[6] However, they also reported that vein graft should not be advocated, if the possibility of a meaningful functional recovery of the digit is low. The similar success rate between the two groups in the study might be due to selection bias. In contrast, in the proximal amputation group, there was also no statistically significant difference in the success rate of both subgroups with and without vein grafts, regardless of whether there was selection bias in avoiding severe cases.

Whether to dismiss a vein graft if a high success rate or good functioning is unpredictable remains controversial. Prediction of the result or postoperative function pre- and intraoperatively is difficult. As for the treatment of fracture or tendon laceration, surgeons usually do not abandon the surgery, although the results or function recovery

are uncertain.[17] Replantation/revascularization with vein graft should not always be advocated to be abandoned, even if a high success rate or satisfactory function is unpredictable.[18] We did not make such a decision intraoperatively based on the success possibility or postoperative function. Moreover, we performed additional reconstructive surgery to maximize surgical benefit, and attempted to improve the appearance and function.[19]

This study has several limitations. First, this was a retrospective study. Second, the application of the interpositional vein graft was decided by each surgeon depending on the situation and could not be controlled prospectively. Third, the sample size was relatively small, which may have reduced the statistical power. Accordingly, other potential predictors for surgery might not have been identified. Fourth, we did not investigate which of "distal phalanx shortening" or "stump-plasty" was applied for the distal severe cases in which vein grafts were avoided. Finally, the outcome of the study was determined by survival or failure, and we did not consider functional, aesthetic, and patient-related outcomes of replantation/revascularization. Further prospective studies to generalize these findings are warranted.

Despite its limitations, the present study indicates that the success rate was similar between the subgroups with and without vein grafts, in both distal and proximal amputations, which is consistent with other recent reports. However, the clinical implication was different. In the distal amputation group, the absence of a difference in success rate between subgroups was due to selection bias in avoiding small arteries, whereas in the proximal amputation group, there was no difference in success rate even though there was no selection bias in avoiding severe cases. We consider that replantation/revascularization for difficult cases using vein graft should be advocated for.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

ACKNOWLEDGMENT

This study was approved by the ethical committee of our institution (approval number 2019-35).

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