Clinical outcomes of salvage revision surgery following finger replantation with vascular insufficiency: A retrospective study

Özgün Barış Güntürk1, Murat Kayalar1, Ulaş Bali2, Kemal Özaksar1, Tulgar Toros1, Yusuf Gürbüz1

1Clinic of Orthopaedics, Traumatology and Hand Surgery, Emot Hospital, İzmir, Turkey
2Department of Plastic and Reconstructive Surgery, Manisa Celal Bayar University, School of Medicine, Manisa, Turkey

ABSTRACT

Objective: The aim of this study was to analyze the outcomes of revision surgery following replantation of single digital amputations.

Methods: In this study, first, a total of 403 patients (339 male, 64 female; mean age = 28 years; age range = 1-76) in whom a single finger replantation was performed were retrospectively reviewed, and then 60 patients with arterial or venous insufficiency in whom revision surgery was performed were reanalyzed. The second finger was observed to be the most injured one (32.8%). Injury type was classified as clean cut (25.3%), local crush (38.7%), extensive crush (7.9%), and avulsion (21.1%). When taking the levels of injuries of the artery-only finger replantations into account, one finger (0.8%) was nail distal third, 70 fingers (56%) were nail distal third to lunula, 43 fingers (34.4%) were lunula to distal phalanx basis, 10 fingers (8%) were distal interphalangeal (DIP) joint, and one finger (0.8%) was middle phalanx. Operative revision was performed on 60 (14.9%) fingers. The need for operative revision was arterial insufficiency in 37 fingers (61.7%) and venous insufficiency in 23 fingers (38.3%). The average revision time was 43 (range = 6-144) hours. While the average elapsed time for artery procedures was 35.3 (range = 8-110) hours, the average elapsed time for vein procedures was 47.1 (range = 6-144) hours. Finger survival rates were examined. Injury mechanism, amputation level, the number of artery/vein repairs and methods were examined in all patients and revision patients separately.

Results: After the replantations, according to survival analysis, while 342 (84.9%) fingers were operated upon successfully, 61 (15.1%) fingers developed necrosis. In the patients with revision surgery, the survival rate was 78.3%. The need for revision was arterial insufficiency in 37 fingers (61.7%) and venous insufficiency in 23 fingers (38.3%). The revision rate was significantly lower than other injury types in clean-cut cases. In terms of levels of injury, no revisions were required from distal to lunula level, and the highest revision rate was observed at the proximal interphalangeal (PIP) joint level.

Conclusion: The results of the present study have shown that early re-exploration can provide a 78.3% success rate and can increase the survival rate from 67.6% to 84.2% following replantation of single digital amputations. Surgical re-exploration seems to be a reasonable salvage for replanted fingers with vascular insufficiency.

Level of Evidence: Level IV, Therapeutic study

Introduction

While replantation is a challenging intervention, the rate of viability after replantation of the amputated parts is reported to be as high as 90% (1), but there are only a few studies about revision surgery (2, 3). Berlin et al. reported a microvascular revision rate of 19.8% for adults in their series (2). Understanding and awareness of the factors that may affect the circulatory embarrassment will be critical for the decision of revision surgery.

The present study was conducted to analyze revision surgeries in single finger replantations and to analyze the factors that might have an effect on success of finger replantations with or without revision, retrospectively. We assumed that, exclusion of concomitant injuries and multiple finger amputations may clarify contributing factors in the revisions of isolated finger replantations. The question we try to answer is whether a revision surgery would be beneficial for the replanted fingers that have circulatory embarrassment.

Materials and Methods

In our hospital, the cases in which a replantation had been performed between 2000 and 2015 were chosen retrospectively from patient records. This study was approved by the Institutional board (2019-274). Inclusion criterion was selection of patients who had undergone single finger replantations. Exclusion criteria were as follows: patients with diabetes mellitus, patients taking corticosteroids, patients with ipsilateral fracture or injuries rather than finger amputation, and multiple finger replantations or incomplete amputations. 403 patients were analyzed in this study, 60 patients were re-explored in the case of arterial or venous insufficiency. The cases, that had been treated with external bleeding (artery-only replantation) were not taken into consideration as revision cases due to unavailability of veins for revision procedures. Only the cases with a revision surgery were selected as revision cases. Among all the patients, 339 (84.1%) of the patients were male and 64 (15.9%) of them were female. The average age of the patients was 28.86 (range: minimum 1, maximum 76). 31 of the patients...
were younger than 12 years of age. 212 (52.6%) of them had amputation in the right hand and 191 (47.4%) of them had amputation in the left hand. There was no demographic difference between the replantation group and revision group.

Level of injury was classified as nail distal third, nail distal third to lunula, lunula to distal phalanx basis, distal interphalangeal (DIP) joint, middle phalanx/thumb proximal phalanx, proximal interphalangeal (PIP) joint/thumb metacarpophalangeal (MP) joint, and proximal phalanx/thumb metacarpus (Figure 1). The second finger was found to be the most injured one (32.8%). Injury type was classified as clean cut (25.3%), local crush (38.7), extensive crush (7.9%), and avulsion (28.1%) (Figure 2).

Artery repairs were performed using the following methods: (a) end-to-end anastomosis, (b) vein graft interposition, (c) cross anastomosis, (d) artery transfer, (e) arteriovenous, and (f) artery graft interposition. The single artery was repaired in 380 (94.3%) fingers, and both digital arteries were repaired in 23 (5.7%) fingers.

Vein repairs were performed in 278 (69%) fingers. Among the fingers in which vein repair was performed, the repairs were carried out as end-to-end anastomosis, vein graft interposition, vein transfer, arteriovenous, and flow-through venous flap. Only one vein in 143 (51.4%) fingers, 2 veins in 129 (46.4%) fingers, and 3 veins in 6 (2.2%) fingers were repaired.

Vein repair could not be performed in 125 fingers (31%) due to unavailability. When we consider the levels of injuries of these artery-only finger replantations; one finger (0.8%) was nail distal third, 70 fingers (56%) were nail distal third to lunula, 43 fingers (34.4%) were lunula to distal phalanx basis, 10 fingers (8%) were DIP joint, and one finger (0.8%) was middle phalanx. External bleeding was used for venous drainage in these fingers.

Operative revision was performed in 60 (14.9%) fingers. The need for revision was arterial insufficiency in 37 fingers (61.7%) and venous insufficiency in 23 fingers (38.3%). Average revision time was 43 hours after the operation (minimum 6, maximum 144 hours). Average elapsed time for artery procedures was 35.3 hours (minimum 8, maximum 110 hours). Average elapsed time for vein procedures was 47.1 hours (minimum 6, maximum 144 hours). There were only 2 revision surgeries in the artery-only replantation cases. The level of expertise of the surgeons in reporting outcomes of treatment was 4 (4).

Because of the low revision rate in the artery-only replantation cases, we formed 4 sub-groups of cases with at least one venous anastomosis (n=278): (A) cases of successful replantation without revision with at least one artery and one vein anastomosis (n=32), (B) cases of failed replantation who underwent revision surgery with at least one artery and one vein anastomosis (n=12) performed at the first operation.

Cases in sub-group B had a potential for failure if we had not performed the revision surgery. So, without revision surgery, survival groups would be sub-group A versus B+C+D. With revision surgery, survival groups are sub-group A+B versus C+D.

The patient records were reviewed retrospectively. Finger survival rates were examined. Injury mechanism, amputation level, and the number of artery/vein repairs and methods were examined in all patients and revision patients separately. The normality of distribution of continuous variables was tested using the Shapiro-Wilk test. The results showed that the data were normally distributed.

**HIGHLIGHTS**

- Surgical re-exploration provides a reasonable salvage for replanted fingers with vascular insufficiency
- Early re-exploration gives 78.3% success and may increase the survival rate from 67.6% to 84.2%
- Surgeons should be aware of the higher possibility of vascular insufficiency at the PIP level injuries
- Artery-only replantations have low revision rates

![Figure 1. Case distributions according to levels of injury, survival, and revision rates](image1)

![Figure 2. a-d. Classification of injury types. a; Clean cut, b; Local crush, c; Extensive crush, d; Avulsion](image2)
variables was tested by Shapiro-Wilk test. Mann Whitney U test was used to compare 2 independent groups for non-normally distributed data. Chi-square test applied to investigate relationship between 2 categorical variables and Spearman rank correlation coefficient was used to for numerical variables. P value < 0.05 was accepted as statistically significant.

Surgical technique

If amputation was distal to the dip joint, anastomosis of at least 1 artery and 1 vein was attempted. For amputations proximal to the dip joint, the aim was anastomosis of 1 artery and 2 veins. All available vessels are marked by tag sutures in order to make it easier to locate these in case of circulatory embarrassment.

Hypovolemia and hypothermia were avoided in the postoperative period. In the first 6 hours, patients were monitored every half an hour; afterward, an examination was performed every hour for the subsequent 18 hours. Minimum duration of hospitalization was 5 days. Postoperatively, heparin (100 IU/kg/day), acetyl salicylate (0.1 g/day), and Volufen® (10 mL/kg/day) were administered. The first dose of this intravenous fluid regimen was introduced in the operating theatre. Continuous peripheral brachial plexus block was used for postoperative analgesia. During the hospitalization period, bupivacaine (0.125%) was administered through a contiplex catheter (B. Braun Melsungen AG, Melsungen, Germany), which was set under ultrasonographic guidance. Color, temperature, bleeding, capillary filling, pain, and anxiety were recorded by nurses postoperatively.

If circulatory failure was noted; following steps were taken respectively: a) discrimination of arterial/venous failure; b) loosening the wound dressing; c) administration of bolus heparin; d) removal of skin sutures; and e) if clinical improvement is not noted, control of anastomosis in operation theatre, i.e., revision surgery.

During revision surgery, at first, microscopically, leakage from the anastomosis and presence of vascular kinking was controlled. Milking is avoided in order to not push any thrombus distally. After removal of several (2 to 3) stitches at the site of anastomosis, the lumen is controlled for the presence of thrombus. Any thrombus encountered in the lumen can be removed, and proximal flow can be enhanced by irrigation with heparinized saline. In the case of older thrombi involving large vascular segments, another option could be the resection of the vessel until the detection of the healthy lumen. Thrombectomy and reanastomosis, vein grafting, additional venous anastomosis, flow-through venous flaps, and arterial transfer could act as other therapeutic interventions.

### Results

After the replantations, according to survival analysis, while 342 (84.9%) fingers were detected as successful, necrosis developed in 61 (15.1%) fingers.

### Statistical analysis

In the statistical data analysis of all replantations, a significant difference was not detected among the patients’ age and gender considering the survival (p=0.352, 0.794, respectively).

When the relationship between the type of injury and survival was examined, the success rate was detected as 92.2% in clean-cut cases, 85.3% in local crush, 79.6% in avulsion, and 78.1% in extensive crush. There was a significant difference between clean-cut cases and extensive crush, avulsion cases (p=0.035, 0.012, respectively).

The difference was not significant when we excluded the artery-only replantations. When survival was examined in terms of injury level, no significant difference was noted (p=0.233). Number of repaired arteries and veins increased proportionally in terms of the level of injury. This was statistically significant (p=0.001). By grouping the repair types as end-to-end and others, other repair types seem to be used increasingly in the extensive crush and avulsion types. This was also statistically significant (p=0.001).

### Data analysis of the revision group

Surgical procedures were performed on 60 (14.9%) fingers. Among these, 13 (21.7%) surgeries failed. Survival rate was 78.3% in the fingers with revision. By excluding artery-only replantation, when we consider the replantations with the repaired vein, their overall vascular insufficiency rate (either venous or arterial) was 20.9%. This means, vascular insufficiency occurred in one of 5 replantations with repaired vein. The requirements for revision surgery were arterial insufficiency in 37 fingers (61.7%) and venous insufficiency in 23 fingers (38.3%). Specific survival rate was 70.3% for the arterial revision procedures and 91.3% for venous ones (p=0.055).

Considering the fingers with revisions, the time of revision did not have a significant effect on survival (p=0.660). The parameters affecting the need for revision are listed in Table 1.

When the relationship between the type of injury and the need for revision was examined, the revision rate was significantly lower than other injury types in clean-cut cases. We did not find significant difference between local crush, extensive crush, and avulsion types. In terms of levels of injury, there were no revisions distal to lunula (due

| Injury type          | Count | Row N % | Count | Row N % | p      |
|----------------------|-------|---------|-------|---------|--------|
| Clean-cut            | 3     | 2.9     | 99    | 97.1    | 0.001* |
| Local Crush          | 32    | 20.5    | 124   | 79.5    |        |
| Extensive Crush      | 7     | 21.9    | 25    | 78.1    |        |
| Avulsion             | 18    | 15.9    | 95    | 84.1    |        |
| Level of injury      |       |         |       |         |        |
| Nail dista1/3        | 0     | 0.0     | 1     | 100.0   | 0.001* |
| Nail dista1/3 to lunula | 0    | 0.0     | 78    | 100.0   |        |
| Lunula to distal phalanx basis | 3 | 4.3 | 66 | 95.7 | |
| DIP joint            | 12    | 16.4    | 61    | 83.6    |        |
| Middle phalanx / Thumb prox phalanx | 21 | 22.8 | 71 | 77.2 | |
|PIP joint / Thumb MP joint | 8    | 30.8    | 18    | 69.2    |        |
| Proximal phalanx / Thumb metacarp | 16 | 25.0    | 48    | 75.0    |        |
| Vein repair          |       |         |       |         |        |
| Yes                  | 58    | 20.9    | 220   | 79.1    | 0.001* |
| No                   | 2     | 1.6     | 123   | 98.4    |        |

Table 1. The parameters affecting the need for revision
Table 2. Survival rates for fingers, types of injury, levels of injury and procedures in patients with revision surgery (n=60)

| Survival | Successful | Failure |
|----------|------------|---------|
|          | Count       | Row N % | Count         | Row N % | p       |
| Injury type | Clean-cut | 3 | 100.0 | 0 | 0.0 | 0.180 |
| Local Crush | 27 | 84.4 | 5 | 15.6 | |
| Extensive Crush | 6 | 85.7 | 1 | 14.3 | |
| Avulsion | 11 | 61.1 | 7 | 38.9 | |
| Level of injury | Nail distal 1/3 | 0 | 0.0 | 0 | 0.0 | 0.685 |
| Nail distal 1/3 to lunula | 0 | 0.0 | 0 | 0.0 | |
| Lunula to distal phalanx basis | 2 | 66.7 | 1 | 33.3 | |
| DIP joint | 9 | 75.0 | 3 | 25.0 | |
| Middle phalanx / Thumb prox. phalanx | 18 | 85.7 | 3 | 14.3 | |
| PIP joint / Thumb MP joint | 7 | 87.5 | 1 | 12.5 | |
| Proximal phalanx / Thumb metacarpus | 11 | 68.8 | 5 | 31.3 | |
| Finger | 1,00 | 10 | 83.3 | 2 | 16.7 | 0.133 |
| 2,00 | 15 | 68.2 | 7 | 31.8 | |
| 3,00 | 7 | 100.0 | 0 | 0.0 | |
| 4,00 | 7 | 63.6 | 4 | 36.4 | |
| 5,00 | 8 | 100.0 | 0 | 0.0 | |
| Revision type | Vein graft for artery | 7 | 63.6 | 4 | 36.4 | 0.163 |
| Vein graft for vein | 10 | 90.9 | 1 | 9.1 | |
| Artery graft for artery | 1 | 100.0 | 0 | 0.0 | |
| Artery re-anastomosis | 7 | 58.3 | 5 | 41.7 | |
| Vein re-anastomosis | 10 | 90.9 | 1 | 9.1 | |
| Control only | 10 | 90.9 | 1 | 9.1 | |
| Additional vein anastomosis | 1 | 100.0 | 0 | 0.0 | |
| Artery transfer | 1 | 100.0 | 0 | 0.0 | |
| Vein graft for both artery and vein | 0 | 0.0 | 1 | 100.0 | |

Table 3. Parameters for the cases with at least one artery and one vein repairs (n=278) (artery and vein repair type comparisons were performed between "end-to-end and others")

| Sub-groups A versus B+C+D | Sub-groups A+B versus C+D |
|---------------------------|---------------------------|
| Successful | Failure + revised | Successful | Failure |
| Count       | Row N % | Count | Row N % | p | Count | Row N % | Count | Row N % | p |
| Cases | 188 | 67.6 | 90 | 32.4 | 234 | 84.2 | 44 | 15.8 | |
| Injury type | Clean-cut | 29 | 82.9 | 6 | 17.1 | 0.093 | 31 | 88.6 | 4 | 11.4 | 0.746 |
| Local Crush | 72 | 62.1 | 44 | 37.9 | 99 | 85.3 | 17 | 14.7 | |
| Extensive Crush | 15 | 60.0 | 10 | 40.0 | 21 | 84.0 | 17 | 16.0 | |
| Avulsion | 72 | 70.6 | 30 | 29.4 | 83 | 81.4 | 19 | 18.6 | |
| Finger | 1 | 63.8 | 15 | 19.2 | 0.035* | 72 | 89.3 | 6 | 7.7 | 0.075 |
| 2 | 56 | 60.2 | 37 | 39.8 | 71 | 76.3 | 22 | 23.7 | |
| 3 | 14 | 36.0 | 11 | 44.0 | 21 | 84.0 | 4 | 16.0 | |
| 4 | 34 | 69.4 | 15 | 30.6 | 41 | 83.7 | 8 | 16.3 | |
| 5 | 21 | 63.6 | 12 | 36.4 | 29 | 87.9 | 4 | 12.1 | |
| Level of injury | Nail distal 1/3 to lunula | 6 | 75.0 | 2 | 25.0 | 0.877 | 6 | 75.0 | 2 | 25.0 | 0.426 |
| Lumula to DIP | 20 | 76.9 | 6 | 23.1 | 21 | 80.8 | 5 | 19.2 | |
| DIP joint | 40 | 63.5 | 23 | 36.5 | 49 | 77.8 | 14 | 22.2 | |
| Middle phalanx / Thumb prox. pha. | 62 | 68.1 | 29 | 31.9 | 80 | 87.9 | 11 | 12.1 | |
| PIP/Thumb MP j. | 17 | 65.4 | 9 | 34.6 | 24 | 92.3 | 2 | 7.7 | |
| Prox. Pha./1. met. | 43 | 67.2 | 21 | 32.8 | 54 | 84.4 | 10 | 15.6 | |
| Number of artery repair | 1 | 170 | 66.1 | 87 | 33.9 | 0.065 | 214 | 83.3 | 43 | 16.7 | 0.148 |
| 2 | 18 | 85.7 | 3 | 14.3 | 20 | 95.2 | 1 | 4.8 | |
| Artery repair type | End to end | 136 | 68.7 | 62 | 31.3 | 0.552 | 168 | 84.8 | 30 | 15.2 | 0.627 |
| Vein graft | 20 | 64.5 | 11 | 35.5 | 25 | 80.6 | 6 | 19.4 | |
| Cross anastomosis | 5 | 57.1 | 2 | 42.9 | 7 | 100.0 | 0 | 0.0 | |
| Artery Transfer | 24 | 66.7 | 12 | 33.3 | 30 | 83.3 | 6 | 16.7 | |
| Artery graft | 3 | 50.0 | 3 | 50.0 | 4 | 66.7 | 2 | 33.3 | |
| Number of vein repair | 1 | 49 | 68.5 | 45 | 31.5 | 0.945 | 119 | 83.2 | 24 | 16.8 | 0.895 |
| 2 | 86 | 66.7 | 43 | 33.3 | 110 | 85.3 | 19 | 14.7 | |
| 3 | 4 | 66.7 | 2 | 33.3 | 5 | 83.3 | 1 | 16.7 | |
| Vein repair type | End to end | 169 | 68.1 | 79 | 31.9 | 0.595 | 211 | 85.1 | 37 | 14.9 | 0.233 |
| Vein graft | 9 | 60.0 | 6 | 40.0 | 12 | 80.0 | 3 | 20.0 | |
| Vein transfer | 10 | 76.9 | 3 | 23.1 | 11 | 84.6 | 2 | 15.4 | |
| Flow through | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 | 1 | 100.0 | |
| Arteriovenous | 0 | 0.0 | 1 | 100.0 | 0 | 0.0 | 1 | 100.0 | |
to artery-only replantations) and the highest revision rate was at the PIP joint level (p=0.002). This difference was not significant when we excluded the artery-only replantations.

Age, gender, side, finger, artery, and vein repair types did not have significant effects on the need for revision (p=0.86, 0.55, 0.21, 0.61, 0.55, and 0.22, respectively).

We did not detect significant differences in the levels of injury and the types of injury between arterial and venous revised fingers (p=0.434 and 0.475, respectively). Among the 60 fingers with revisions, survival rates, types of injury, levels of injury, and revision procedures are shown in Table 2. No significant difference was found. In the group of patients with replantation failure (n=61), there were 48 patients who did not undergo revision surgery. When we examined these patients for the levels of injuries, 34 of them (70%) were DIP joint or distal levels, 14 of them were proximal to DIP joint. Injury types for these patients were avulsion in 7 cases, extensive crush in 2 cases, and local crush in 5 cases. There was no clean-cut injury in this group.

There were 2 revision surgeries in the cases without vein anastomosis (artery-only replantations). One of them was artery reanastomosis and the other one was control only.

**Regarding the cases with at least one artery and one vein:** Survival rate would be 67.2% if we had not performed any revision surgeries. By the help of revision surgery, this rate is 84.2%. Data for these sub-groups’ comparisons are shown in Table 3. When we compare the sub-groups A and B, clean cut cases were significantly lower in the revision cases and the third finger had the highest revision rate (p=0.027 and 0.032, respectively), among the survived fingers. Other factors did not have a significant effect. When we compare the sub-groups A and C, second finger had the highest risk for failure, among fingers without revision (p=0.015). Other factors did not have a significant effect. When we compared the sub-groups C and D, and B and D, we did not find any significant effect.

**Discussion**

The survival rates are generally between 70% and 97% in the replantation series (5-9). Vascular insufficiency after replantation surgery can be related to several factors, injury related, patient related, etc. But this is the earliest complication and usually requires meticulous inspection for salvage of digits (10). Reported suture anastomosis failure rates range from 2% to 10% (11).

Vascular insufficiency rates have been reported in up to 63% of such cases in the literature and are commonly related to venous insufficiency (12-15). The risk of thrombosis decreased significantly to 10% after 72 hours, and the vast majority of arterial thrombi were detected in the first 24 hours (16). Arterial insufficiencies are generally encountered in lesser numbers and earlier than the venous ones (13, 16). But there is no rule about that (3, 5). Our findings showed the early onset of venous insufficiency but arterial insufficiency was more common than the venous one (61.7% versus 38.3%). Sammartin et al. reported thrombosis within 3 days in unsuccessful replantation cases (17). However salvage procedures may not be cost effective and may lengthen hospital stays, but it is 70% and 91% effective in arterial and venous insufficiencies, respectively.

There are 2 approaches in the literature. One is non-operative measures and the other is operative measures. Non-operative measures for venous congestion include chemical and medicinal leeching, and they are usually used in distal replantations. When the injury level is more proximal, operative approach is much more logical to solve thrombotic event because of large vessel caliber. Otherwise, the possibility of tissue metabolite accumulation due to insufficiency gets higher. In case of venous insufficiency, one of the following methods can be chosen: reanastomosis, vein grafting, flow-through venous flap, or cross finger flap (18). We strongly believe that the surgeon’s armamentarium should involve all tricks about current anastomosis techniques, such as second artery anastomosis, delayed venous anastomosis, arteriovenous anastomosis, etc.

In artery-only replantations, which were 125 digits in our series, we performed only 2 revisions. We think that artery-only replantation is a straightforward procedure with low revision rates. We have got no vein and usually just one artery available. So, there is not much option for revision. In the case of venous insufficiency, we perform external bleeding.

Hatchell et al., reported the success of salvage procedures in digital replantations (13). Vascular insufficiency rate was 63% and it looks like a little bit more than usual. Venous insufficiency was more frequent than arterial (71% versus 29%). They commonly utilized medicinal leeches for proximal replantations with vascular insufficiency (82% of their failure cases). But exploration was performed in only 2 cases. Most of their cases had been treated nonoperatively. The overall salvage rate was 44%.

Chia et al. have also conducted a study about troubled replantations (10). They reported vascular insufficiency as 35.2%. In their series, most of the insufficiencies were arterial. Re-exploration had been done in 20% of the troubled cases. The overall salvage rate was 51%.

The rate of reoperation due to thrombosis in patients who received antithrombotic prophylaxis varies between 6% and 25% (12). Our re-exploration rate is about 14%. We strongly believe that close observation and early detection is the gold standard. When we consider the failed replantation cases, we realized that some cases (n=48) with vascular insufficiency had not been operated as a revision surgery. The reasons were related to the availability of veins and injury mechanism (5, 14, 19). In case of vascular insufficiency, the decision of exploration generally depends on surgeon’s experience and vessel availability. We generally observe available vessels during the initial surgery and tag them for later use. If there are available extra veins, they can be tagged with sutures for later venous insufficiency repairs. If there is no vein, external bleeding or any other methods can be used when it is necessary. If there is an available artery, it should also be tagged for further arteriovenous or arterial anastomosis as well. Delay in vascular insufficiency treatment is also an important factor, which may affect the survival rates. Delay in re-exploration may deteriorate the status of available vessels by propagation of thrombosis.

Replantation results were supposed to be better if 2 or more veins were repaired during the procedure (5, 17, 20). Repair of 2 arteries was found to yield better survival rates after replantation (21). Therefore, we suggest that repair of both arteries must be attempted during replantation to achieve more favorable therapeutic results, especially in bad prognostic injuries. There are usually 2 bigger veins on each side of the finger on the proximal phalanx level, these veins created an arcade in the area proximal to the PIP joint. 50.96% of the veins at the PIP joint level are 0.3-0.5 mm in diameter (22). These thin veins may be compressed with the increasing edema in the postoperative period. In this level, valves may also have a role in thrombosis. Sukop et al. reported that venous valves are always located distally from the bifurcation of veins (22). PIP joint level had the highest risk of
revision surgery in our series. However, it was not significant when we excluded the artery-only replantation cases, which were mostly distally leveled.

It is interesting that the type of vascular revision and the time of the revision had no effect on survival on revision surgery. We think that type of revision had no effect because we perform any procedure that is necessary to solve vascular insufficiency. Time of revision also did not affect because we perform early revision procedures when we detect vascular insufficiency.

Although there are better results in the literature, we speculate that close clinical observation, early re-exploration, and good quality vascular anastomosis as the reasons for 84.9% survival rate. Our survival rate after revision is as high as 78.3%. The revised cases would certainly have ended up in failure, if they were not revised. Because of the low revision rate in artery-only replantations, we also analyzed the cases with at least one artery and one vein. According to this, our survival rate, which is 84.2%, would be 67.6% if we had not performed revision surgeries. Therefore, the revision surgery increases the survival rate for replantation, and it is beneficial in our opinion.

Gender, religion, and cultural factors may influence the decision for replantation (7,23). In addition to cost effectiveness analysis, analysis of socio-demographic parameters must be analyzed during decision making for replantation surgery. Highly specialized training centers not only report improved success rates, but also, their tendency for replantation decision was higher than the other institutions (6,14,24). We perform replantation surgery by 7/24 h basis. But attitudes of surgeons are changing and some delayed suspended replantations have been reported (13).

Limitations of the present study include retrospective design, lack of sensorial and functional data, and possible impacts of social, economic, ethnic, and environmental factors on therapeutic outcomes. Furthermore, this retrospective analysis is one of the largest series reported from our country. Thus, we hope that our results may provide novel insights and encourage implementation of further trials on digital replantation.

Our results indicate that replanted parts should be carefully observed to delineate vascular insufficiency. Early re-exploration gives 78.3% success and may increase the survival rate from 67.6% to 84.2%. Surgeons should be aware of the higher possibility of vascular insufficiency at thePIP level injuries. Every possible vessel should be tagged in the initial procedure for later use. Another outcome of the study is that artery-only replantations have low revision rates. In conclusion, surgical re-exploration provides a reasonable salvage for replanted fingers with vascular insufficiency, and it is beneficial. We favor close monitoring and early surgical re-exploration.

Ethics Committee Approval: Ethics committee approval was received for this study from the Institutional Board of Emot Hospital (2019-274).

Informed Consent: Informed consent was obtained from all the individual participants included in the study.

Author Contributions: Concept - Ö.B.G., M.K.; Design - Ö.B.G., M.K.; Supervision - M.K., T.T.; Materials - K.O., Y.G., T.T., Ö.B.G., M.K.; Data Collection and/or Processing - U.B., Ö.B.G.; Analysis and/or Interpretation - Ö.B.G., U.B.; Literature Search - K.O., Y.G., M.K.; Writing Manuscript - Ö.B.G., M.K.; Critical Review - T.T., M.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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