

## Brief communication (Original)

# Complications and secondary surgeries after free flap for limb reconstruction at King Chulalongkorn Memorial Hospital: a ten-year retrospective review of patient data

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**Background:** Free flap surgery is an essential tool in limb reconstruction, but complex and often followed by complications, with many cases requiring additional procedures.

**Objectives:** To analyze postoperative complications and need for secondary surgery after free flap surgery over a 10-year period at King Chulalongkorn Memorial Hospital.

**Methods:** We retrospectively reviewed data from a cohort of patients who underwent free flap surgery for limb reconstruction from 2004 to 2014.

**Results:** We included 35 free flap operations in 29 patients. Mean follow-up time was 6.4 y. Free flap surgical procedures included 7 gracilis transfers, 8 toe transfers, 5 latissimus dorsi flaps, 5 fibular transfers, 4 anterolateral thigh flaps, 2 lateral-arm flaps, 2 radial forearm flaps, and 2 venous free flaps. There were 4 categories of postoperative complications. (1) Patients were those who developed total flap loss after free flap surgery (7/35 flaps, 20%). (2) Patients had major complications requiring additional operations (11/35 flaps, 31%). Major complications included partial flap necrosis, wound swelling with delayed closure, arterial occlusion, postoperative bleeding, infection, and failed implant fixation. (3) Patients had minor complications that required no additional surgical procedures (8/33 flaps, 23%). (4) Patients with no postoperative complications (9/35 flaps, 26%). Secondary surgery after initial free flap was 51% overall (18/35 flaps). The 3 most common secondary procedures included second flap coverage, skin graft, and anastomosis revision. We found free flap surgery performed during the subacute period (14–90 d after injury) to have significantly ( $P = 0.028$ ) more complications (categories 1 and 2) than surgery performed during the acute period ( $<14$  d) or late reconstruction ( $>90$  d).

**Conclusions:** Physicians should be prepared for a range of outcomes of free flap surgery and advise their patients of the risk of additional operations accordingly.

**Keywords:** Secondary surgery, flap necrosis, free flap surgery, limb reconstruction postoperative complications

Microsurgical free tissue transfer is a valuable tool in reconstructive surgery. Currently, the success rate of free flap surgery is more than 95.0% (overall flap loss rate ranges 1.4%–4.8%) [1–9]. Although free flap surgery may be performed by experienced surgeons and a well-prepared team, complications still arise that often require additional surgical interventions after the initial surgery. This is especially the case in free flap surgery for extremity reconstruction. Previous studies have shown a higher flap loss rate (8.4%–20.0%) [10–13], higher complication rate

(25.2%–40.0%) [8, 11, 12, 14], and a need for additional surgical interventions, including anastomosis revision, bleeding control, limb amputation, and debridement with or without soft tissue coverage by a secondary free flap, regional flap, local flap, or skin graft [3, 4, 11, 13]. The objective of this retrospective study was to analyze and report postoperative complications and the need for additional surgical interventions after free flap surgery for upper and lower extremity reconstructions at our center over 10 years (2004–2014). Multiple factors that may be associated with complications and a need for additional surgery were analyzed. The clinical questions of the present study were: (1) what is the rate of postoperative complications and the need for

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secondary procedures after free flap for limb reconstruction in our institute? (2) Which factors may relate to the complications and the need for additional surgery after free flap surgery?

### Patients and methods

The Institutional Review Board (IRB) of the Faculty of Medicine, Chulalongkorn University approved the retrospective review of patient data and the present study (Certificate of approval No. 1037/2016, IRB No. 681-59).

### Patient characteristics

This retrospective cohort review evaluated patients who underwent free flap surgery for reconstruction of upper or lower extremities at the Department of Orthopaedics, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital from January 2004 to January 2014. Following our inclusion and exclusion criteria, data from all consecutive patients were included in the present study without bias selection. Our inclusion criteria were: (1) all patients who underwent microvascular free tissue transfer, (2) complete medical records, and (3) at least 1-year follow up after the surgery. The exclusion criteria for the present study were: (1) patients with incomplete medical records, and (2) patients with less than 1 year follow up after surgery or loss to follow up.

Demographic and clinical data of all patients were collected and analyzed. Complications and additional operations were reported for each patient. The results of free flap surgery in this study were classified into 4 categories, which were defined as follows:

Category 1: total flap loss (loss of more than 75% of flap volume).

Category 2: major complications (excluding total flap loss requiring additional surgical interventions).

Category 3: minor complications (complications that did not require additional surgical interventions).

Category 4: no postoperative complications or additional surgical interventions.

All free flap cases were then evaluated for predisposing factors that may have been associated with complications and a need for additional surgery. Patients were divided into one of two groups, according to postoperative outcome. Patients requiring additional surgery and classified into either category 1 or 2 were assigned to Group A. Patients not requiring

additional surgery and classified into category 3 or 4 were assigned to Group B. Factors that were analyzed included age, sex, location of soft tissue or bone defect, time to surgery, flap type, operative time, artery-to-vein ratio during microsurgical anastomosis, vessel anastomosis technique (end-to-end or end-to-side), intraoperative blood loss, and length of hospital stay.

### Statistical analyses

Complications and secondary surgical procedures were reported as percentages. Predisposing factors between Group A (requiring secondary surgery) and Group B (not requiring secondary surgery) were compared using Fisher's exact test.  $P < 0.05$  was considered significant. Statistical analyses were performed using SPSS Statistics for Windows, version 17.0 (SPSS Inc).

### Results

We investigated 35 free flaps in 29 patients in the present study. Mean follow-up time was 6 y 5 mo (range: 1 y to 11 y 3 mo). There were 23 male and 6 female patients, their mean age was 29.2 y (range: 6–58 y). Mean time from onset of injury to free flap surgery was 1 y 9 mo (range: immediately to 17 y). Specifically, 10 flap procedures were performed <14 days, 11 from 14 to 90 days, and 14 >90 days after injury. Mean operative time was 8.9 h (range: 4.0–13.5 h). Mean estimated blood loss was 469.3 mL. Mean length of hospital stay was 30.4 days (range: 6 days to 180 days). Clinical data including the types of operations, causes of injury, and indications for surgery are shown in **Table 1**.

The most common cause of injury was from traffic accidents, followed by injuries from industrial machines. Indications for free flap surgery included soft tissue defect at lower extremity and foot, soft tissue defect at wrist and forearm, and soft tissue defect at hand and finger. Types of free flap operations included in the present study were latissimus dorsi (LD) flaps, toe transfers, free vascularized fibular grafts, and gracilis free functioning muscle transfer (FFMT).

Of the 35 free flaps, we found that 26 (74%) flaps had postoperative complications and 18 (51%) needed secondary procedures after initial free flap operation. Only 9 (26%) flaps were free of any complications (**Table 2**).

**Table 1.** Clinical data for 35 free flaps (29 patients)

| Operations (No. flaps) | Injury cause (No. flaps) | Indications for surgery (No. flaps)            |
|------------------------|--------------------------|--|
| LD flap (5)            | Traffic accident (21)    | Soft tissue defect leg/foot (8)                |
| Toe transfer (8)       | Blast injury (3)         | Soft tissue defect wrist/forearm (4)           |
| Gracilis FFMT (7)      | Electrical burn (2)      | Soft tissue defect hand/finger (4)             |
| Fibular graft (5)      | Machine                  | Bone defect: tibia (3), femur (1), humerus (1) |
| Lateral arm (2)        | Industrial (8)           | Thumb loss (6)                                 |
| Radial forearm (2)     | Tumor resection (1)      | Finger joint loss (2)                          |
| ALT flap (4)           |                          | Post-arm replantation (1)                      |
| Venous-free flap (2)   |                          |  |

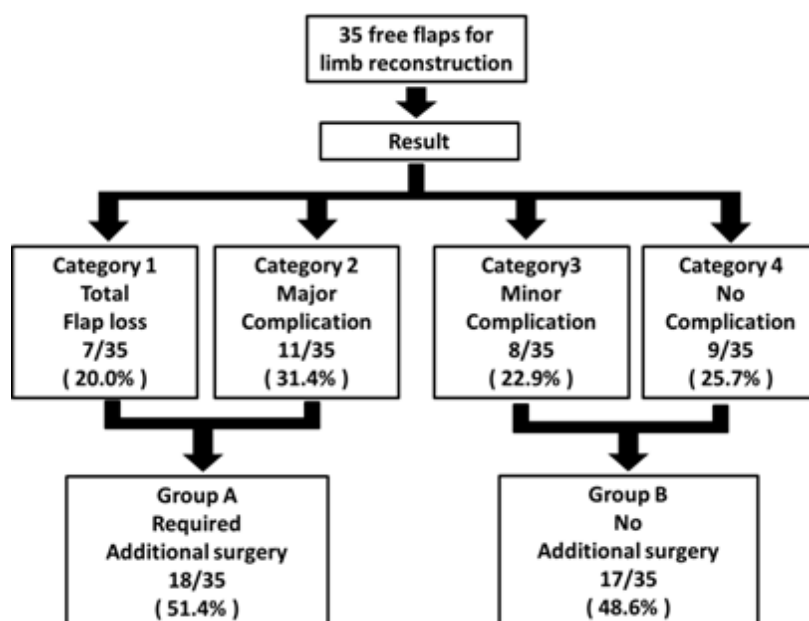
LD, latissimus dorsi; FFMT, free functioning muscle transfer; ALT, anterolateral thigh.

**Table 2.** Complications and secondary operations after free flap surgery

| Complications                               | No. of flaps<br>(N = 35) | %    | Notes                         |
|---|--------------------------|------|-------------------------------|
| Flap necrosis                               | 16                       | 46   |                               |
| Total                                       | 7                        | 20   |                               |
| Partial                                     | 9                        | 26   |                               |
| Acute flap ischemia                         | 6                        | 17   | 5/6 flaps had total flap loss |
| Wound swelling                              | 3                        | 9    | Required STSG                 |
| Bleeding                                    | 2                        | 6    |                               |
| Infection                                   | 5                        | 15   | 2/5 flaps had total flap loss |
| Implant failure                             | 1                        | 3    |                               |
| Donor-site wound dehiscence (toe)           | 1                        | 3    |                               |
| Rhabdomyolysis                              | 1                        | 3    |                               |
| Sciatic nerve injury                        | 1                        | 3    |                               |
| Total flaps with complications              | 26                       | 74   |                               |
| Total flaps without complications           | 9                        | 26   |                               |
| <b>Secondary operations</b>                 |                          |      |                               |
| Pedicle revision                            | 3                        | 9    | 2/3 flaps had total flap loss |
| Second flap coverage                        | 7                        | 20   |                               |
| Free flap                                   | 3                        | 9    | Coverage total flap loss      |
| Local                                       | 3                        | 9    | Coverage partial flap loss    |
| Regional                                    | 1                        | 3    | Groin flap                    |
| Debridement + antibiotic bead               | 2                        | 6    |                               |
| Debridement + VAC                           | 1                        | 2.9  |                               |
| Amputation                                  | 2                        | 5.7  | 1 BK, 1 finger                |
| STSG  | 6                        | 17.1 |                               |
| Stop bleeding in operation room             | 1                        | 2.9  |                               |
| Implant revision                            | 1                        | 2.9  | Revision tibial plate         |
| Total flaps requiring secondary surgery     | 18                       | 51.4 |                               |
| Total flaps not requiring secondary surgery | 17                       | 48.6 |                               |

Abbreviations: ALT: Anterolateral thigh; BK: Below knee; STSG: Split-thickness skin graft; VAC: Vacuum-assisted closure

Complications of free flaps in this study were classified into 4 categories as shown in **Figure 1**.



**Figure 1.** Result of free flap surgery for limb reconstruction in the Department of Orthopaedics, King Chulalongkorn Memorial Hospital 2004–2014

Details relating to complications and additional operations in each category are described as follows:

### Category 1: total flap loss

Seven cases had total flap loss (20%), consisting of latissimus dorsi flap, ALT flap, lateral arm flap, 2nd toe transfer, and venous free flap. Mean age of Category 1 patients at initial operation was 21.1 y. Mean length of their hospital stay was 72 days and mean operative time was 9.7 h.

Total flap loss because of arterial insufficiency usually occurred on the first or second day after surgery. Delayed flap necrosis that occurred >2 days after surgery was typically the result of infection. After total flap failure, patients usually had a longer length of hospital stay and required multiple additional procedures, such as flap revision, debridement with soft tissue coverage (groin flap, radial forearm flap, and LD flap), debridement with antibiotic bead insertion, vacuum dressing, and amputation (**Table 3**—Category 1).

### Category 2: complications excluding total flap loss requiring additional surgical intervention

Eleven cases developed complications that required additional surgery within the first week after the initial operation (31%). Fibular, LD, gracilis FFMT, ALT flap, toe joint, and venous free flaps were included in this group. Mean age of Category 2 patients was 28.3 years. Mean length of their hospital stay

was 30.5 days and mean operative time was 8.6 h.

Complications in this group included: partial flap necrosis, treated by local flap coverage or debridement with skin graft; postoperative swelling, treated by delayed skin graft at postoperative day 7; flap ischemia, treated by exploration with pedicle revision on postoperative day 1; postoperative bleeding, treated in the operating room; infection, treated by debridement and antibiotic bead insertion; and failed implant fixation, treated by tibia plate revision. Complications and secondary operations in each case are shown in **Table 3**—Category 2.

### Category 3: minor complications not requiring additional surgical intervention

Eight cases developed minor complications that did not require additional operations. Mean age of Category 3 patients was 29.6 years. Mean length of their hospital stay was 15.3 days. ALT, radial forearm, toe transfer, gracilis, and fibular free flaps were included in this category. Complications observed in this group were partial flap necrosis, wound drainage with osteomyelitis, postoperative bleeding, donor-site wound dehiscence (at the big toe), rhabdomyolysis, and sciatic nerve injury. All cases were treated successfully by conservative treatment without additional surgery. Complications that developed in each case are presented in **Table 3**—Category 3.

**Table 3.** Detail of complications and secondary operations following free flap surgery (Categories 1, 2, and 3)

| <b>Category 1</b>      | <b>n</b> | <b>Operation</b>  | <b>Indications for surgery</b>                 | <b>Detail of complications</b>   | <b>Secondary procedures</b>      |
|------------------------|----------|-------------------|--|----------------------------------|----------------------------------|
| Total flap loss        | 7        | LD flap           | Exposed plate ankle                            | Flap ischemia (day 1)            | Radial forearm flap              |
|                        |          | LD flap           | Soft tissue loss at tibia                      | Flap ischemia (day 1)            | Radial forearm flap              |
|                        |          | Venous-free flap  | Soft tissue loss at middle finger              | Flap ischemia (day 1)            | Finger amputation                |
|                        |          |                   | Compartment with exposed distal radius plate   | Flap ischemia (day 1)            | Debride + antibiotic bead insert |
|                        |          | Lateral arm flap  | Blast injury with bilateral thumb loss         | Flap ischemia (day 2)            | LD flap                          |
|                        |          | 2nd toe transfer  | Degloving skin at leg                          | Infection (day 21)               | Pedicle revision                 |
|                        |          | LD flap           | Compartment syndrome with exposed tibial plate | Infection (day 28)               | Groin flap                       |
| <b>Category 2</b>      | <b>n</b> | <b>Operation</b>  | <b>Indications for surgery</b>                 | <b>Detail of complications</b>   | <b>Secondary procedures</b>      |
|                        |          | 2nd toe transfer  | Crush injury with finger joint loss            | Soft tissue defect               | Posterior Interosseous flap      |
|                        |          | Fibular free flap | Segmental tibial bone defect                   | Soft tissue defect exposed tibia | Gastrocnemius flap               |
|                        |          | Fibular free flap | Segmental tibial bone defect                   | Skin necrosis, exposed tibia     | Rotational flap                  |
|                        |          | Venous free flap  | Electrical burn with defect at finger          | Partial skin loss                | Debridement + STSG               |
|                        |          | ALT flap          | Degloved hand                                  | Partial flap necrosis            | Debridement + STSG               |
|                        |          | Fibular free flap | Tibial bone loss                               | Partial skin necrosis            | Debridement + STSG               |
| Partial flap necrosis  | 6/11     | 2nd toe transfer  | Crush injury with finger joint loss            | Swelling                         | STSG                             |
|                        |          | Gracilis FFMT     | Post-arm replantation                          | Swelling                         | STSG                             |
|                        |          | Gracilis flap     | Fx both bone leg with plate exposed            | Swelling                         | STSG                             |
|                        |          | Fibula free flap  | Post-tumor resection                           | Flap ischemia (postop day 1)     | Revision anastomosis             |
|                        |          | LD flap           | Soft tissue defect forearm                     | Postoperative bleeding (day 4)   | Explore pedicle + stop bleeding  |
|                        |          | LD flap           | Compartment exposed radius plate               | Chronic osteomyelitis            | Antibiotic bead insertion        |
|                        |          | Fibular free flap | Segmental tibial bone defect                   | Loosening screw fixation         | ORIF with locking plate tibia    |
| <b>Category 3</b>      | <b>n</b> | <b>Operations</b> | <b>Indications for surgery</b>                 | <b>Detail of complications</b>   | <b>Secondary procedures</b>      |
| Partial flap necrosis  | 3/8      | Gracilis FFMT     | Brachial plexus injury—total arm               | Partial flap necrosis            | No                               |
|                        |          | ALT flap          | Fx forearm (S/P fail lateral arm flap)         | Tip of flap necrosis             | No                               |
| Wound drainage         | 2/8      | Fibular free flap | AVN + COM proximal humerus                     | Superficial skin loss            | No                               |
|                        |          | Radial forearm    | Fx both bone left leg                          | Sinus drainage with COM          | No                               |
| Bleeding               | 1        | ALT flap          | Soft tissue loss lateral side of foot          | Postop sinus drainage            | No                               |
|                        |          | Radial forearm    | Fx ankle with fail LD flap                     | Postop bleeding                  | No                               |
| Donor wound dehiscence | 1        | Wrap around       | Failed thumb replantation                      | Wound at big toe                 | No                               |
| Rhabdomyolysis         | 1        | 2nd toe transfer  | Bilateral thumb loss                           |                                  | No                               |
| Sciatic nerve injury   | 1        | 2nd toe transfer  | Bilateral thumb loss                           |                                  | No                               |

LD, latissimus dorsi; BK, below knee; ALT, anterolateral thigh; STSG, split-thickness skin graft; FFMT, free functioning muscle transfer; ORIF, open reduction and internal fixation; COM, chronic osteomyelitis

#### Category 4: no complications and no additional surgery

Nine free flap surgery patients had no complications and no need for additional surgery. Mean age for patients in this category was 36 years. Mean length of their hospital stay was 14.4 days. The 9 flaps in this group consisted of 4 cases of gracilis FFMT for BPI reconstruction, 4 toe transfers for thumb reconstruction (2 wrap-around flaps, 1 whole great toe transfer, and 1 second toe joint transfer), and 1 lateral arm free flap for coverage of a hand degloving injury.

In the present study, we compared multiple

factors that might be associated with the result of free flap surgery between patients that develop serious complications and require additional surgical interventions (Group A) and patients that do not require additional operations (Group B; minor complication or no postoperative complication). The only factor found statistically different between the 2 groups was time from initial injury to free flap surgery. We found free flap surgery performed during the subacute period (14–90 days) to have significantly more complications than the surgery performed during the acute period (<14 days) or late reconstruction (>90 days) (**Table 4**).

**Table 4.** Factors associated with outcome of free flap surgery

| Factor                               | Group A: major complications <sup>a</sup><br>(n = 18 free flaps)                       | Group B: minor/no complication <sup>b</sup><br>(n = 17 free flaps) |
|--------------------------------------|--|--|
| 1. Mean age (y)                      | 25.5   | 32   |
| 2. Sex (male:female)                 | 15:3   | 14:3   |
| 3. Injury cause (No. of flaps)       | MCA (10), blast (1), electrical burn (2), industrial accident (4), tumor resection (1) | MCA (11), blast (2), industrial accident (3)                       |
| 4. Location of defect                |  |  |
| Soft tissue upper extremity          | 6  | 3  |
| Soft tissue lower extremity          | 5  | 3  |
| Bone defect                          | 4 [tibia (3), femur (1)]   | 1 (humerus)  |
| Hand/finger                          | 2  | 5  |
| 5. Time to surgery (No. of flaps)    |  |  |
| <14 days                             | 4  | 6  |
| 14–90 days*                          | 9  | 2  |
| >90 days                             | 5  | 9  |
| 6. Type of flap (No. of flaps)       |  |  |
| Soft tissue transfer                 | 9 [LD (5), ALT (2), lateral arm (1), venous flap (2)]                                  | 5 [radial forearm (2), ALT (2), lateral arm (1)]                   |
| Fibular graft transfer               | 4  | 1  |
| Toe to hand transfer                 | 2  | 6  |
| Gracilis free muscle transfer        | 2  | 5  |
| 7. Artery:vein ratio (No. of flaps)  |  |  |
| 1:1                                  | 13   | 9  |
| >1:1                                 | 5  | 8  |
| 8. Vessel anastomosis (No. of flaps) |  |  |
| End-to-end                           | 13   | 14   |
| End-to-side                          | 5  | 3  |

<sup>a</sup>Group A: free flap with major complications that required additional surgery (Categories 1 and 2)

<sup>b</sup>Group B: free flap with minor or no complications that did not require additional surgery (Categories 3 and 4)

\*Indicates significant difference between Groups A and B ( $P = 0.028$ )

MCA, motorcycle accident; ALT, anterolateral thigh; LD, latissimus dorsi



## Discussion

Free flap surgery is a complex surgical procedure that requires an experienced surgeon and an experienced surgical support team. Even in an optimal clinical setting, complications can develop after free flap surgical procedures. Moreover, and in most cases, secondary surgical procedures are necessary to correct these complications. This study found 3 levels of postoperative complications after free flap surgery, including: total flap failure, major complications requiring surgical correction, and minor complications not requiring additional surgery. Only about a quarter of our patients had no complications after free flap surgery. The 3 most common complications in our series were flap necrosis, acute flap ischemia, and infection.

Common secondary surgical procedures included anastomosis revision; control of bleeding; debridement; soft tissue coverage by secondary free flap, regional flap, local flap, or skin graft; and amputation. We found that around half of cases (categories 1 and 2) developed postoperative complications that required additional surgical intervention within the first week after the initial surgery. The other half of cases (categories 3 and 4) did not require secondary surgical procedures. The most common secondary operations were secondary flap coverage, skin graft, and pedicle revision. Once acute flap ischemia developed after initial free flap surgery, there was a high risk of total flap loss, and the success rate after pedicle revision was low. Based on these findings, we strongly recommend that surgeons check vascular status immediately after surgery and closely follow the patient, especially in the immediate postoperative period. In any case where ischemia is suspected, the condition should be corrected during initial surgery or during secondary surgery as soon as possible after the initial procedure.

Various types of salvage procedures can be used after the development of flap necrosis. Secondary free flap surgery can be performed with a higher risk of flap failure (2.8% in primary free flap surgery compared with 17.7% in secondary free flap surgery) [4]. In the present review, secondary free flap surgery was performed in cases of total flap necrosis that required a large volume of soft tissue coverage. A local flap is usually the best choice for a salvage procedure to cover the defect, especially in partial flap necrosis with minimal soft tissue loss. Regional flaps (e.g. groin flap) are normally recommended

in cases with poor feeding vessels, poor soft tissue environment, or severe scar adhesion in the area of the defect. Skin graft and wound dressing with healing by secondary intention can be performed in cases of partial flap necrosis without exposure of vital structures. In cases of flap necrosis with a large volume of devitalized tissue, severe infection, or poor associated medical conditions, or all of these conditions, limb amputation may be indicated to preserve the life of the patient.

Multiple factors may be related to a higher rate of free flap failure and postoperative complications, including muscle free flap (compared with fasciocutaneous free flap) [2]; proximal location of injury; open fracture grade 3C; osteomyelitis; flap requiring anastomosis revision or vein graft [5]; high American Society of Anesthesiologists score status; long operative time [15]; tobacco use; and, patients who had multiple risk factors for arteriosclerosis [16]. In the present study, multiple factors in free flap surgery were compared between Group A (patients that develop serious complications and require additional surgical interventions and Group B (patients do not require any additional surgery, minor or no postoperative complication). For uncontrollable factors like age, sex, operative time, and injury type, we found no difference between groups. There was also no significant difference between groups for location of soft tissue defects. Bone defect reconstruction (especially in lower extremities) showed higher risk of complications and usually required additional surgery, but we did not find significant difference with the small sample size.

For controllable factors, including time from initial injury to free flap surgery, choice of flap, surgical technique (end-to-end or end-to-side anastomosis), and number of veins per artery, only time from initial injury to free flap surgery was found to be different between the groups. We found flaps performed during the subacute period to have significantly more complications than free flaps that were performed during the acute period or late reconstructions. This finding supports those of Godina who reported higher complication rates in free flap surgery performed during a subacute period (3 days to 3 months) [17]. We recommend that free flap surgery be performed as soon as possible (within 2 weeks is preferred) in cases where extremities require any type of free flap coverage or free tissue reconstruction. To achieve optimal conditions for flap surgery, the surgeon needs

to ensure the following: careful and meticulous debridement to eliminate all devitalized tissue and infection; provision of an adequate stable skeletal framework, and adequate patient resuscitation to improve tolerance of any long and complex microsurgical reconstruction procedure.

In some cases, where the condition of the patient or wound is not optimal for free flap surgery and vital structures such as bone or tendon are not exposed, free flap reconstruction can be delayed to achieve soft tissue equilibrium before performing free flap transfer. From our findings, we recommended a 3-month period from the initial injury before performing late free flap reconstructions.

We did not find any association for other controllable factors, such as artery-to-vein ratio or anastomosis technique (end-to-end or end-to-side) and the result of free flap transfer in the present study. From this data and to decrease operative time, we recommend identifying at least 1 ideal arterial and 1 ideal venous anastomosis with end-to-end anastomosis. We recommend reserving the end-to-side technique for other specific vessel conditions, such as surgery in single vessel limb, large vessel disproportion, or surgeon preference.

A limitation of our study was the small sample size. A larger sample size might reveal more detailed associations with controllable factors.

In summary, free flap surgery in limb reconstruction is a complex procedure that is normally followed by complications and secondary operations. We classified complications that might occur after reconstruction surgery into 4 levels, including total flap loss, major complications, minor complications, and free of complications. More than half of cases required additional surgery. Accordingly, physicians who perform free flap operations should be prepared for this range of outcomes and accordingly advise their patients regarding the risk of additional operations after free flap surgery.

#### Author contributions

PL, PK, and SH substantially contributed to the study conception and design, PL reviewed medical records and collected data, PL and SH analyzed and interpreted the data; PL and PK drafted the manuscript, and PL and SH critically revised it; all authors read and approved the final version submitted for publication and take responsibility for the statements in this article.

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#### Conflict of interest statement

There is no conflict of interest associated with any of the authors of this manuscript.

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