Microsurgical Lower Extremity Reconstruction in the Subacute Period: A Safe Alternative

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Background: Microsurgical reconstruction of the lower extremity is an integral part of the limb salvage algorithm. Success is defined by a pain-free functional extremity, with a healed fracture and sufficient durable soft tissue coverage. Although early flap coverage of lower extremity fractures is an important goal, it is not always feasible because of multiple factors. Between the years 2000 and 2010, approximately 50% of patients at Los Angeles County and University of Southern California Medical Center requiring microsurgical reconstruction did not receive soft tissue coverage until more than 15 days postinjury secondary to primary trauma, physiologic instability, patient comorbidities, or orthopedic and plastic surgery operative backlog. The objective of our study was to evaluate outcomes in patients who underwent microsurgical reconstruction of the lower extremity, in relation to the timing of reconstruction.

Methods: A retrospective chart review was performed for patients requiring immediate lower extremity reconstruction from January 2000 to December 2009 at LAC + USC.

Results: Fifty-one patients were identified in this study. The most common mechanisms of injury were motorcycle, motor vehicle, and fall accidents. Eighty-six percent of injuries were open and 74% were comminuted. The distal 1/3 of the tibia, including the tibial pilon, was the most common location of injury. When comparing patients reconstructed in less than 15 days versus greater than or equal to 15 days, there was no significant difference in rates of flap failure, osteomyelitis, bony union, or ambulation.

Conclusion: Microsurgical reconstruction of the lower extremity in the subacute period is a safe alternative. (Plast Reconstr Surg Glob Open 2015;3:e449; doi: 10.1097/GOX.0000000000000399; Published online 14 July 2015.)
tremity trauma reconstruction, several studies have emerged challenging it by showing that with flaps being performed outside this critical “early window,” can result in equivalent success.10–12

Although early flap coverage of open lower extremity fractures is an important goal, it is not always feasible because of patient and hospital factors. The LAC + USC medical center serves as catchall for polytrauma in a city of 4 million people. Between the years 2000 and 2010, approximately 50% of patients with acute lower extremity wounds requiring microsurgical reconstruction at our institution did not receive soft tissue coverage until greater than 2 weeks postinjury secondary to primary trauma, physiologic instability, patient comorbidities, or orthopedic and plastic surgery operative backlog. The objective of our study was to evaluate outcomes in patients who underwent microsurgical reconstruction of the lower extremity, in relation to the timing of reconstruction. Specifically, we chose to evaluate patients reconstructed earlier than 15 days after injury versus those at 15 days or later, reflecting the subacute time period as cited by previous authors.

METHODS

Records from the Division of Plastic and Reconstructive Surgery, University of Southern California, were used to identify patients who underwent lower extremity reconstruction with microsurgical flaps at LAC + USC Medical center from January 1, 2000 to December 31, 2009. Patients were excluded if their primary indication for free flap was clinical osteomyelitis after fracture, as we felt these patients represented a different subset of injury. A retrospective chart review was performed for patients when complete or nearly complete inpatient medical records were available.

Patient records were reviewed for data points categorized into independent and dependent variables during the subsequent statistical analysis. Independent variables included patient demographics (age, gender, comorbidities, preinjury ambulation, and trauma team triage), injury characteristics [including mechanism, injury severity score, abbreviated injury scale (AIS) extremity, location, and severity], reconstructive procedures (including time to flap, type of flap, and total number of reconstructive procedures), and follow-up (number of physical therapy sessions, number of occupational therapy sessions, and length of follow-up). Dependent variables included flap survival, development of osteomyelitis, radiographic evidence of bony union, and postinjury ambulation. Radiographic bony union was assessed by a board-certified radiologist or orthopedic surgeon reviewing all pertinent x-rays or imaging as available. Osteomyelitis was diagnosed by clinical records available in the chart and cultures when available. Ambulation was defined clinically by the evaluating orthopedic doctor.

Two groups were compared using the Wilcoxon 2-sample test for continuous variables and the 2-sided Fisher’s exact test for categorical variables. For each outcome measure and for each risk factor, the odds ratio and its 95% confidence intervals were derived to assess the association of the risk factor with the outcome. The Biomedical Package (BMDP) Statistical Software was used for all analysis (Dixon, 1985).

RESULTS

Demographic and Injury Characteristics

Fifty-one patients were identified with lower extremity injuries requiring primary microsurgical reconstruction during the time period (Table 1). The study population was 86% male (44 of 51) with an average age of 39±15 years. All patients ambulated independently before their injury. Social comorbidities were common, including tobacco (28%, 14 of 51), alcohol (31%, 16 of 51), and drug abuse (33%, 17 of 51). Physiologic comorbidities were less common but present with 22% (11 of 51) of patients having hypertension and 6% (3 of 51) of patients having diabetes.

The most common mechanisms of injury were motorcycle accident (20%, 10 of 51), auto versus pedestrian accident (20%, 10 of 51), and fall (20%, 10 of 51). The most common locations of bony injury were distal 1/3 tibia (33%, 17 of 51) and tibial pilon (33%, 17 of 51). Patient injuries were most commonly open (86%, 44 of 51) and comminuted (74%, 38 of 51). The soft tissue deficit was <50 cm² in 17% (7 of 40), 50–150 cm² in 38% (15 of 40), and >150 cm² in 45% (18 of 40). In patients with known severity scores, the injury severity score in 14% (5 of 37) was >16, and the abbreviated injury score (AIS) of the extremity was greater than or equal to 3 in 78% (28 of 36). Seventy-two percent (37 of 51) of patients were triaged as a polytrauma victim by the acute care surgery team at the time of arrival.

The length of time between injury and free flap was <15 days in 45% (23 of 51) and ≥15 days in 55% (28 of 51). The most common free flaps performed during this time period were rectus abdominis (49%, 25 of 51) and latissimus dorsi (28%, 14 of 51). Most patients underwent 1–4 total (bony and soft tissue) reconstructive procedures (67%, 34 of 51), whereas 33% (17 of 51) underwent 5–9 procedures. Table 2 shows a complete breakdown of patient reconstructive procedures. The average length of clinical follow-up was 491±640 days.
Flap Failure
Five patients (10%, 5 of 51) had total flap failure, although 2 went on to repeated and successful microsurgical reconstruction with an alternate flap (Table 3). In comparing patients who had total flap failure (N = 5) with those who did not (N = 46), the only significant variable was age, with flap failure more common in older individuals (50 ± 9 vs 38 ± 15, P = 0.04). The timing of reconstructive procedure, AIS of the extremity, number of reconstructive procedures, location of injury, fracture comminution, and open injury were not significant risk factors.

Osteomyelitis
Nine patients developed osteomyelitis after their flap was performed (Table 4). There were no significant differences in demographic or injury characteristics, including time to reconstruction, between patients who had osteomyelitis and those who did not. Patients who developed osteomyelitis underwent significantly more total procedures [5–9 procedures: 67% (6 of 9) with osteomyelitis vs 28% (10 of 36) without osteomyelitis; P = 0.05] and isolated bony reconstructive procedures [6+ procedures: 33% (3 of 9) with osteomyelitis vs 0% without osteomyelitis, P = 0.01] overall. An increased number of bony procedures before free flap did not increase the rate of osteomyelitis.

Bony Union
There were 21 patients with radiographic bony union information available for long-term assessment at a minimum of 6 months (Table 5). Thirty patients had insufficient electronic radiographic evidence or were transferred, sent back to jail, or lost to follow-up before the 6 month interval. Seventy-six percent (16 of 21) of patients had definitive union at 6 months, whereas 24% (5 of 21) were either delayed or non-healing. There were no significant demographic or injury characteristics between the 2 groups nor differences in their reconstructive procedures.

Ambulation
There were 26 patients with documented ambulation data available at 6 months (Table 6). At 6 months or at their discharge from care, 11 (42%) patients were ambulating independently, 10 (38%) ambulated with an assistive device, such as crutches or
a walker, and 5 (19%) patients were still non-weight bearing per their clinician.

**DISCUSSION**

Early surgical pioneers demonstrated that adequate debridement of necrotic tissue and infection before wound closure was required for healing of any wound, particularly in traumatic injuries of the lower extremity.13,14 Experiences with lower extremity salvage in the Vietnam conflict led to support for early aggressive debridement of traumatic wounds, surgical stabilization of fractures, and soft tissue coverage once the wound had stabilized.15–20 The recognition of importance of soft tissue coverage in healing lower extremity injuries paralleled the development of flap techniques to close them. In the 1980s, microsurgical techniques were refined, and Godina and coworkers demonstrated that highest flap failure and complication rates occurred when microsurgical reconstruction was performed 1–6 weeks postinjury.5,6 As a result of these landmark studies, a doctrine of lower extremity salvage was adopted that included early debridement, fracture stabilization, and vascularized tissue coverage within 1 week.

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### Table 3. Flap Failure by Demographic and Clinical Subgroups

| Demographic characteristics | Total | Had Flap Failure | No Flap Failure | P*  |
|-----------------------------|-------|------------------|----------------|-----|
| Age (y), mean ± SD (n)      | 39±15 (51) | 50±9 (5) | 38±15 (46) | 0.04† |
| Male, % (n)                 | 86 (44/51) | 100 (5/5) | 85 (39/46) | 1.00 |
| Tobacco use, % (n)          | 28 (14/51) | 40 (2/5) | 26 (12/46) | 0.61 |
| Alcohol abuse, % (n)        | 31 (16/51) | 60 (3/5) | 28 (13/46) | 0.31 |
| Drug abuse, % (n)           | 33 (17/51) | 20 (1/5) | 35 (16/46) | 0.65 |
| Hypertension, % (n)         | 22 (11/51) | 40 (2/5) | 20 (9/46) | 0.29 |
| Diabetes, % (n)             | 6 (3/51) | 0 (0/5) | 7 (3/46) | 1.00 |

| Injury characteristics      |       |                 |               |     |
|-----------------------------|-------|------------------|---------------|-----|
| Mechanism of injury, % (n)  |       |                 |               |     |
| MCA                         | 20 (10/51) | 40 (2/5) | 17 (8/46) | 0.62 |
| AVP                         | 20 (10/51) | 20 (1/5) | 20 (9/46) | 0.62 |
| Fall                        | 20 (10/51) | 20 (1/5) | 20 (9/46) | 0.62 |
| GSW                         | 18 (9/51) | 0 (0/5) | 20 (9/46) | 0.62 |
| MVA                         | 14 (7/51) | 0 (0/5) | 100 (7/46) | 0.62 |
| Industrial-crush            | 8 (4/51) | 20 (1/5) | 7 (3/46) | 0.62 |
| Dog bite                    | 2 (1/51) | 0 (0/5) | 2 (1/46) | 0.62 |

| Location of bony traumatic injury, % (n) |       |                 |               |     |
|------------------------------------------|-------|------------------|---------------|-----|
| None                                      | 2 (1/51) | 0 (0/5) | 2 (1/46) | 0.37 |
| Proximal 1/3 tibia                       | 12 (6/51) | 0 (0/5) | 13 (6/46) | 0.37 |
| Middle 1/3 tibia                         | 4 (2/51) | 20 (1/5) | 2 (1/46) | 0.37 |
| Distal 1/3 tibia                         | 33 (17/51) | 20 (1/5) | 35 (16/46) | 0.37 |
| Tibial pilon                             | 33 (17/51) | 60 (3/5) | 30 (14/46) | 0.37 |
| Calcaneus                                | 2 (1/51) | 0 (0/5) | 2 (1/46) | 0.37 |
| Foot                                     | 14 (7/51) | 0 (0/5) | 15 (7/46) | 0.37 |
| Open, % (n)                              | 86 (44/51) | 100 (5/5) | 85 (39/46) | 0.37 |

| Comminuted, % (n)                       | 74 (38/51) | 80 (4/5) | 74 (34/46) | 0.37 |

| Soft tissue deficit, % (n)               |       |                 |               |     |
|------------------------------------------|-------|------------------|---------------|-----|
| <50 cm²                                  | 17 (7/40) | 33 (1/3) | 16 (6/37) | 0.39 |
| 50–150 cm²                               | 38 (15/40) | 0 (0/3) | 41 (15/37) | 0.39 |
| >150 cm²                                 | 45 (18/40) | 67 (2/3) | 43 (16/37) | 0.39 |
| ISS >16, % (n)                            | 14 (5/37) | 0 (0/4) | 15 (5/33) | 1.00 |

| AIS extremity, % (n)                      |       |                 |               |     |
|------------------------------------------|-------|------------------|---------------|-----|
| 2                                        | 22 (8/36) | 0 (4/4) | 25 (8/32) | 0.14 |
| 3                                        | 75 (27/36) | 75 (3/4) | 75 (24/32) | 0.14 |
| 4                                        | 3 (1/36) | 25 (1/4) | 0 (0/32) | 0.14 |

| Reconstructive procedure                  |       |                 |               |     |
|------------------------------------------|-------|------------------|---------------|-----|
| Length of time between injury and free flap, % (n) |       |                 |               |     |
| <15 d                                    | 45 (23/51) | 60 (3/5) | 43 (20/46) | 0.65 |
| 2–15 d                                   | 55 (28/51) | 40 (2/5) | 57 (26/46) | 0.65 |

| Type of free flap, % (n)                  |       |                 |               |     |
|------------------------------------------|-------|------------------|---------------|-----|
| Rectus                                   | 49 (25/51) | 60 (3/5) | 48 (22/46) | 1.00 |
| Latissimus dorsi                         | 28 (14/51) | 20 (1/5) | 28 (13/46) | 1.00 |
| Gracilis                                 | 18 (9/51) | 20 (1/5) | 17 (8/46) | 1.00 |
| Other                                    | 6 (3/51) | 0 (0/5) | 7 (3/46) | 1.00 |

| Total number reconstructive procedures, % (n) |       |                 |               |     |
|----------------------------------------------|-------|------------------|---------------|-----|
| 1–4                                          | 67 (34/51) | 60 (3/5) | 67 (31/46) | 1.00 |
| 5–9                                          | 33 (17/51) | 40 (2/5) | 33 (15/46) | 1.00 |

*Based on Fisher’s exact test (comparing “had flap failure” group and “no flap failure” group).
†Based on Wilcoxon 2-sample test (comparing “had flap failure” group and “no flap failure” group).
ISS, injury severity score.
### Table 4. Incidence of Osteomyelitis

| Demographic characteristics | Total | Osteomyelitis | No Osteomyelitis | $P^*$ |
|-----------------------------|-------|---------------|-----------------|-------|
| **Age, mean ± SD (n)**     | 38±14 (45) | 40±17 (9) | 38±14 (36) | 0.88† |
| **Male, % (n)**            | 87 (39/45) | 78 (7/9) | 89 (32/36) | 0.58 |
| **Triaged by trauma team, % (n)** | 73 (35/45) | 89 (8/9) | 69 (25/36) | 0.41 |
| **Tobacco use, % (n)**     | 29 (13/45) | 11 (1/9) | 33 (12/36) | 0.25 |
| **Alcohol abuse, % (n)**   | 29 (13/45) | 44 (4/9) | 25 (9/36) | 0.41 |
| **Drug abuse, % (n)**      | 31 (14/45) | 44 (4/9) | 28 (10/36) | 0.43 |
| **Hypertension, % (n)**    | 20 (9/45) | 33 (3/9) | 17 (6/36) | 0.35 |
| **Diabetes, % (n)**        | 4 (2/45) | 0 (0/9) | 6 (2/36) | 1.00 |
| **Injury characteristics** |       |               |                 |       |
| **Mechanism of injury, % (n)** |       |               |                 |       |
| MCA                         | 22 (10/45) | 22 (2/9) | 22 (8/36) | 0.85 |
| AVP                         | 20 (9/45) | 22 (2/9) | 19 (7/36) |       |
| Fall                        | 22 (10/45) | 11 (1/9) | 25 (9/36) |       |
| GSW                         | 16 (7/45) | 22 (2/9) | 14 (5/36) |       |
| MVA                         | 13 (6/45) | 22 (2/9) | 11 (4/36) |       |
| Industrial/crush            | 7 (3/45) | 0 (0/9) | 8 (3/36) |       |
| Dog bite                    | 0 (0/45) | 0 (0/9) | 0 (0/36) |       |
| **Location of bony traumatic injury, % (n)** |       |               |                 |       |
| None                        | 0 (0/45) | 0 (0/9) | 0 (0/36) | 0.70 |
| Proximal 1/3 tibia          | 13 (6/45) | 22 (2/9) | 11 (4/36) |       |
| Middle 1/3 tibia            | 4 (2/45) | 0 (0/9) | 6 (2/36) |       |
| Distal 1/3 tibia            | 36 (16/45) | 44 (4/9) | 33 (12/36) |       |
| Tibial pilon                | 29 (13/45) | 33 (3/9) | 28 (10/36) |       |
| Calcaneus                   | 2 (1/45) | 0 (0/9) | 3 (1/36) |       |
| Foot                        | 16 (7/45) | 0 (0/9) | 19 (7/36) |       |
| Open                        | 84 (38/45) | 78 (7/9) | 86 (31/36) | 0.61 |
| Comminuted, % (n)           | 76 (34/45) | 78 (7/9) | 75 (27/36) | 1.00 |
| **Soft tissue deficit, % (n)** |       |               |                 |       |
| <50 cm²                     | 20 (7/35) | 29 (2/7) | 18 (5/28) | 0.75 |
| 50–150 cm²                  | 34 (12/35) | 29 (2/7) | 36 (10/28) |       |
| >150 cm²                    | 45 (16/35) | 45 (5/7) | 46 (13/28) |       |
| ISS >16, % (n)              | 12 (4/33) | 13 (1/8) | 12 (3/25) | 1.00 |
| **AIS extremity, % (n)**    |       |               |                 |       |
| 2                           | 22 (7/32) | 0 (0/7) | 28 (7/25) | 0.34 |
| 3                           | 75 (24/32) | 100 (7/7) | 68 (17/25) |       |
| 4                           | 3 (1/32) | 0 (0/7) | 4 (1/25) |       |
| **Reconstructive procedure**|       |               |                 |       |
| **Length of time between injury and free flap, % (n)** |       |               |                 |       |
| <15 d                       | 49 (22/45) | 56 (5/9) | 47 (17/36) | 0.72 |
| ≥15 d                       | 51 (23/45) | 44 (4/9) | 53 (19/36) |       |
| **Type of free flap, % (n)** |       |               |                 |       |
| Rectus                      | 47 (21/45) | 33 (3/9) | 50 (18/36) | 0.71 |
| Latissimus dorsi            | 31 (14/45) | 44 (4/9) | 28 (10/36) |       |
| Gracilis                    | 18 (8/45) | 22 (2/9) | 17 (6/36) |       |
| Other                       | 4 (2/45) | 0 (0/9) | 6 (2/36) |       |
| **Total number reconstructive procedures, % (n)** |       |               |                 |       |
| 1–4                         | 64 (29/45) | 33 (3/9) | 72 (26/36) | 0.05 |
| 5–9                         | 36 (16/45) | 67 (6/9) | 28 (10/36) |       |
| **Isolated soft tissue procedures, % (n)** |       |               |                 |       |
| 1                           | 73 (33/45) | 89 (8/9) | 69 (25/36) | 0.53 |
| 2                           | 24 (11/45) | 11 (1/9) | 28 (10/36) |       |
| 3–4                         | 2 (1/45) | 0 (0/9) | 3 (1/36) |       |
| **Isolated vascular procedures, % (n)** |       |               |                 |       |
| 0                           | 93 (42/45) | 78 (7/9) | 97 (35/36) | 0.10 |
| 1–2                         | 7 (3/45) | 22 (2/9) | 3 (1/36) |       |
| **Isolated bony procedures, % (n)** |       |               |                 |       |
| 0–2                         | 51 (23/45) | 33 (3/9) | 56 (20/36) | 0.01 |
| 3–5                         | 42 (19/45) | 33 (3/9) | 44 (16/36) |       |
| 6+                          | 7 (3/45) | 33 (3/9) | 0 (0/36) |       |
| **Isolated bony procedures before free flap, % (n)** |       |               |                 |       |
| 0–2                         | 67 (30/45) | 67 (6/9) | 67 (24/36) | 1.00 |
| 3+                          | 33 (15/45) | 33 (3/9) | 33 (12/36) |       |

*Based on Fisher’s exact test (comparing “osteomyelitis” group and “no osteomyelitis” group).
†Based on Wilcoxon 2-sample test (comparing “osteomyelitis” group and “no osteomyelitis” group).
ISS, injury severity score.
Multiple recent studies have demonstrated that there is a reasonable success rate outside this time window.\textsuperscript{10,21–23} We evaluated the outcomes at our center, because by circumstance, many patients are unable to be reconstructed within the recommended time period. Our study demonstrates that there was no significant difference in rates of flap failure, post-flap osteomyelitis, bony union, or ambulation rates in patients reconstructed after 15 days from injury compared with those constructed before 15 days.

If patients developed osteomyelitis, they were more likely to require additional procedures and experience delayed healing, as expected. However, increasing the number of washouts or isolated bony procedures did not increase the rate of osteomyelitis or flap failure nor decrease ambulation rates.

Our findings are supported by other studies. In 2004, Wei and colleagues\textsuperscript{11} reported outcomes in lower extremity reconstructions performed at an average of 27 days postinjury. Flap survival was 89%.

### Table 5. Bony Union at 6 Months by Demographic and Clinical Subgroups

| Demographic and Clinical Subgroups | Total | Had Bony Union | Delayed or Nonunion | P*  |
|-----------------------------------|-------|---------------|---------------------|-----|
| **Demographic characteristics**   |       |               |                     |     |
| Age, mean ± SD (n)                | 39±14 (16) | 39±14 (16)  | 31±17 (5)           | 0.28† |
| Male, % (n)                       | 81 (17/21) | 81 (15/16)  | 80 (4/5)            | 1.00 |
| Triaged by trauma team, % (n)     | 81 (17/21) | 81 (15/16)  | 80 (4/5)            | 1.00 |
| Tobacco use, % (n)                | 19 (4/21)  | 25 (4/16)    | 0 (0/5)             | 0.55 |
| Alcohol abuse, % (n)              | 38 (8/21)  | 38 (6/16)    | 40 (2/5)            | 1.00 |
| Drug abuse, % (n)                 | 29 (6/21)  | 31 (5/16)    | 20 (1/5)            | 1.00 |
| Hypertension, % (n)               | 29 (6/21)  | 38 (6/16)    | 0 (0/5)             | 0.26 |
| Diabetes, % (n)                   | 0 (0/21)   | 0 (0/16)     | 0 (0/5)             | NA   |
| **Injury characteristics**        |       |               |                     |     |
| Mechanism of injury, % (n)        |       |               |                     |     |
| MCA                               | 24 (5/21) | 19 (3/16)    | 40 (2/5)            | 0.84 |
| AVP                               | 24 (5/21) | 25 (4/16)    | 20 (1/5)            |      |
| Fall                              | 14 (3/21) | 13 (2/16)    | 20 (1/5)            |      |
| GSW                               | 14 (3/21) | 13 (2/16)    | 20 (1/5)            |      |
| MVA                               | 19 (4/21) | 25 (4/16)    | 0 (0/5)             |      |
| Industrial/crush                  | 5 (1/21)  | 6 (1/16)     | 0 (0/5)             |      |
| Dog bite                          | 0 (0/21)  | 0 (0/16)     | 0 (0/5)             |      |
| Location of bony traumatic injury, % (n) |       |               |                     |     |
| None                              | 0 (0/21)  | 0 (0/16)     | 0 (0/5)             | 0.54 |
| Proximal 1/3 tibia                | 10 (2/21) | 6 (1/16)     | 20 (1/5)            |      |
| Middle 1/3 tibia                  | 0 (0/21)  | 0 (0/16)     | 0 (0/5)             |      |
| Distal 1/3 tibia                  | 38 (8/21) | 31 (5/16)    | 60 (3/5)            |      |
| Tibial pilon                      | 35 (7/21) | 38 (6/16)    | 20 (1/5)            |      |
| Calcaneus                         | 5 (1/21)  | 6 (1/16)     | 0 (0/5)             |      |
| Foot                              | 14 (3/21) | 19 (3/16)    | 0 (0/5)             |      |
| Open, % (n)                       | 90 (19/21) | 88 (14/16)  | 100 (5/5)           | 1.00 |
| Comminuted, % (n)                 | 86 (18/21) | 81 (13/16)  | 100 (5/5)           | 0.55 |
| Soft tissue deficit, % (n)        |       |               |                     |     |
| <50cm²                            | 14 (2/14) | 18 (2/11)    | 0 (0/3)             | 0.71 |
| 50–150 cm²                        | 50 (7/14) | 55 (6/11)    | 33 (1/3)            |      |
| >150 cm²                          | 36 (5/14) | 27 (3/11)    | 67 (2/3)            |      |
| ISS >16, % (n)                    | 24 (4/17) | 31 (4/15)    | 0 (0/4)             | 0.52 |
| AIS extremity, % (n)              |       |               |                     |     |
| 2                                 | 19 (3/16) | 25 (3/12)    | 0 (0/4)             | 0.53 |
| 3                                 | 81 (13/16) | 75 (9/12)   | 100 (4/4)           |      |
| 4                                 | 0 (0/16)  | 0 (0/12)     | 0 (0/4)             |      |
| **Reconstructive procedure**      |       |               |                     |     |
| Length of time between injury and free flap, % (n) |       |               |                     |     |
| <15 d                             | 52 (11/21) | 44 (7/16)   | 80 (4/5)            | 0.31 |
| ≥15 d                             | 48 (10/21) | 56 (9/16)   | 20 (1/5)            |      |
| Type of free flap, % (n)          |       |               |                     |     |
| Rectus                            | 43 (9/21) | 38 (6/16)    | 60 (3/5)            | 0.85 |
| Latissimus dorsi                  | 38 (8/21) | 38 (6/16)    | 40 (2/5)            |      |
| Gracilis                          | 14 (3/21) | 19 (3/16)    | 0 (0/5)             |      |
| Other                             | 5 (1/21)  | 6 (1/16)     | 0 (0/5)             |      |
| Total number reconstructive procedures, % (n) |       |               |                     |     |
| 1–4                               | 57 (12/21) | 69 (11/16)  | 20 (1/5)            | 0.12 |
| 5–9                               | 43 (9/21)  | 31 (5/16)   | 80 (4/5)            |      |

*Based on Fisher’s exact test (comparing “had bony union” group and “delayed or non-union” group).
†Based on Wilcoxon 2-sample test (comparing “had bony union” group and “delayed or nonunion” group).
ISS, injury severity score.
postoperative infection was 7.9%, union rate was 96.7%, and average union time was 8.5 months. In a 2009 review of grade III lower extremity Operation Iraqi combat casualties, Kumar et al.24 examined local and free flap reconstruction in 43 patients. Timing of the reconstruction ranged from 7 to 82 days, with an average of 21.3 days, allowing for approximately 5 pre-reconstructive washouts and transport time from the battlefield. In their review, only 1 patient suffered flap loss, 2 patients required reoperation, and 98% of patients had eventual wound healing without need for amputation. As part of the Lower Extremity Assessment Project study group in 2007, Webb et al.12 found the timing of debridement, and soft tissue coverage had no significant effect on outcome. These findings suggest that patients with difficult injuries may require more invasive operations overall, but adequate debridement and fracture treatment before microsurgical soft tissue reconstruction, even if it requires additional time, is an essential tenet of salvage.

Our study is limited by its small sample size and in certain areas, incomplete long-term data. Statistical significance should be interpreted with caution as the power of study was limited by its numbers. The application of the electronic medical record is relatively new at our institution, and we are actively investigating longer term results. However, we felt these findings were important to publish as they do demonstrate that microvascular reconstruction of the injured extremity is safe in the “subacute” period, and timing alone should not deter the surgeon from performing limb salvage when a wound is adequately debrided and stabilized.

CONCLUSIONS

Lower extremity salvage outcomes were not related to the timing of microvascular reconstruction. Further studies are needed to elucidate the potential risk or benefit of successive procedures before soft tissue coverage. In particular patients, serial debridement of tissue more than 1–2 weeks as the wound “demarcates” may not only be prudent but necessary. Larger prospective studies are needed to evaluate the optimal balance between number of procedures and time.

Table 6. Patient Postoperative Ambulation at Minimum 6 Months

|                      | Ambulating Independently, % | Ambulating with AD, % | Non-Weight Bearing, % | P*  |
|----------------------|-----------------------------|-----------------------|-----------------------|-----|
| Flap failure         |                             |                       |                       |     |
| All                  | 42 (11/26)                  | 38 (10/26)            | 19 (5/26)             | 0.58|
| Patients without flap failure | 44 (11/25)                  | 36 (9/25)             | 20 (5/25)             |     |
| Patients with flap failure | 0 (0/1)                     | 100 (1/1)             | 0 (0/1)               |     |
| Osteomyelitis        |                             |                       |                       |     |
| All                  | 46 (11/24)                  | 38 (9/24)             | 17 (4/24)             | 0.20|
| No osteomyelitis     | 56 (10/18)                  | 33 (6/18)             | 11 (2/18)             |     |
| Patients with osteomyelitis | 17 (1/6)                    | 50 (3/6)              | 33 (2/6)              |     |
| Bony union           |                             |                       |                       |     |
| All                  | 44 (7/16)                   | 50 (8/16)             | 6 (1/16)              | 1.00|
| Patients without bony union =1 | 43 (6/14)                   | 50 (7/14)             | 7 (1/14)              |     |
| Patients with bony union =2, 3 | 50 (1/2)                    | 50 (1/2)              | 0 (0/0)               |     |

*Based on Fisher’s exact test (comparing “ambulating independently” group, “ambulating with AD” group, and “non-weight bearing” group).

AD, assistive device.

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