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Ghazi Abdulhalim Al-Ariki, PhD

Fahmi Abdulhalim Al-Ariki, PhD

Najla Alhmadi, M.D

The Departments of Plastic Surgery and General Surgery, Faculty of Medicine, Taiz University

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Ghazi Abdulhalim Al-Ariki, PhD

Fahmi Abdulhalim Al-Ariki, PhD

Najla Alhmadi, M.D

The Departments of Plastic Surgery and General Surgery, Faculty of Medicine, Taiz University

Abstract

Background: War-related lower extremity injuries post complex reconstructive challenges due to high-energy trauma, extensive soft tissue loss, and delayed presentation

Methods: This prospective descriptive study included 200 consecutive patients presenting with leg, knee, and ankle injuries requiring soft tissue reconstruction at Al-Thawra Hospital, Taiz, Yemen, over 19 months. A standardized orthoplastic protocol was followed, including meticulous debridement, early or delayed reconstruction using skin grafts, local fasciocutaneous, or muscle flaps. Patient demographics, injury mechanism, defect characteristics, reconstructive modality, complications, and outcomes were recorded.

Results: Most patients were male (93.5%), with high-velocity projectile injuries being predominant (61.5%). Reconstruction was performed with split-thickness skin grafts in 54%, flaps in 40%, and primary closure in 6% of cases. Early reconstruction (<72h) was associated with significantly shorter hospital stay and lower osteomyelitis rates ($p<0.001$).

Conclusions: Timely orthoplastic reconstruction, guided by defect characteristics and resource availability, yields favorable outcomes in conflict-related lower limb trauma. Early intervention reduces complications and hospitalization, emphasizing the importance of integrated multidisciplinary care in resource-limited settings.

Introduction

War-related trauma remains a major contributor to morbidity and mortality in conflict zones, particularly in resource-limited settings. Extremity injuries constitute a large proportion of war-related trauma, with the lower limbs frequently affected, reflecting both the mechanism of wounding and the relative exposure of limbs in modern conflict.The pattern of injury in modern warfare has shifted toward high-energy mechanisms, most notably blasts from improvised explosive devices (IEDs), gunshot wounds, and complex crush injuries (1,2). Unlike civilian trauma, which is typically associated with blunt mechanisms such as motor vehicle collisions, these injuries result in extensive composite tissue loss involving critical neurovascular structures and open fractures, and are associated with high rates of infection, nonunion, and long-term disability (3,4). As a result, the nature of these injuries is inherently more complex, reflecting the combined effects of blast forces and wound contamination. Accordingly, their management requires advanced and context-specific reconstructive approaches that go beyond conventional fracture care, posing significant challenges in austere surgical environments (2).

Epidemiological data analyses of civilian and combatant trauma across contemporary conflicts, extremity injury rates have been reported at approximately 33.5 % of all injuries1, with blast mechanisms responsible for the majority of cases and gunshot wounds comprising a substantial fraction (1,5,6). The protracted armed conflict in Taiz, Yemen, has similarly resulted in a substantial rise in traumatic injuries involving multiple body regions, with a particularly high burden of lower extremity trauma requiring complex surgical intervention. This article reviews the core principles and reconstructive techniques applicable to the management of complex lower extremity trauma in wartime conditions, and evaluates the epidemiological features, reconstructive methods, and outcomes in a conflict setting in Taiz, Yemen.

Methods

Study Design and Setting

A prospective descriptive cohort study was conducted in the Plastic and Burn Units of Al-Thawra Hospital, Taiz, Yemen, a tertiary referral center managing a high volume of complex extremity trauma, predominantly related to armed conflict. The study was carried out over a 19-month period from February 1, 2024, to March 31, 2025.

During this interval, 200 consecutive patients presenting with traumatic soft tissue defects involving the leg, knee, or ankle requiring surgical reconstruction were enrolled. Patients were admitted through the emergency department or outpatient clinics and assessed by a multidisciplinary orthoplastic team comprising plastic surgeons, orthopedic surgeons, and general surgeons, consistent with established orthoplastic care models.

Ethical Considerations

Ethical approval for the study was obtained from the institutional review board of Al-Thawra Hospital. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants or their legal guardians prior to inclusion in the study.

Inclusion Criteria

Patients were included if they met the following criteria:

- Individuals of any age and either sex.
- Traumatic injuries associated with soft tissue loss involving the leg, knee, or ankle region.
- Wounds requiring surgical reconstruction using skin grafts or flap coverage.
- Provision of informed consent by the patient or a legal guardian.

Exclusion Criteria

Patients were excluded if they had:

- Chronic non-traumatic ulcers (e.g., diabetic foot ulcers or venous ulcers).
- Severe systemic infection or terminal illness that contraindicated surgical intervention.
- Loss to follow-up prior to postoperative wound evaluation.

Data Collection

Data were prospectively collected using a standardized case report form. The following variables were recorded: demographic data (age, sex), mechanism of injury (e.g., blast, gunshot, crush), anatomical location of the defect, defect size and depth, presence of exposed critical structures (bone, tendon, neurovascular structures), reconstructive modality utilized, postoperative complications (infection, flap/graft failure, hematoma, wound dehiscence), and clinical outcomes, including wound healing and functional recovery.

Surgical Management Protocol

All patients underwent comprehensive wound assessment upon admission. Initial management consisted of meticulous surgical debridement to remove necrotic tissue and reduce bacterial contamination, in line with established principles of open fracture and soft tissue management. Reconstruction was performed once the wound bed was deemed suitable. Definitive reconstruction was performed once a clean, well-vascularized wound bed had been achieved. The timing and method of reconstruction were determined according to orthoplastic principles, emphasizing early soft tissue coverage when feasible.

Reconstructive strategies were individualized based on defect characteristics, including size, depth, anatomical location, and the presence of exposed vital structures.

The following techniques were utilized:

- Split-thickness skin grafts (STSGs): used for superficial, well-vascularized defects without exposed critical structures.
- Local muscle flaps, including gastrocnemius and soleus flaps, for coverage of exposed bone or tendon, particularly in proximal and middle third leg defects.
- Fasciocutaneous flaps: employed for moderate soft tissue defects when reliable local perforators were available.
- Primary closure: performed in small wounds where closure could be achieved without excessive tension.

Free tissue transfer was not performed due to limited microsurgical resources at the institution.

Postoperative Management

Postoperative care included close monitoring for flap viability, graft adherence, infection, hematoma formation, and wound dehiscence. Wound dressings were changed under sterile conditions. Antibiotics and analgesics were administered according to institutional treatment protocols, and established trauma care guidelines. Early mobilization and structured physiotherapy were initiated once wound stability was achieved to optimize functional outcomes and reduce morbidity.

Follow-Up and Outcome Assessment

Patients were followed weekly for the first four weeks after surgery and subsequently on a monthly basis for up to three months. Primary outcome measures included successful wound healing and complication rates. Secondary outcomes included functional limb recovery and patient-reported satisfaction.

Statistical Analysis

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS), version 25.0. Continuous variables were summarized as means and standard deviations, while categorical variables were presented as frequencies and percentages. Descriptive statistics were used to analyze patient characteristics, injury patterns, reconstructive methods, and clinical outcomes. Normally distributed data were presented as mean ± standard deviation (SD) and compared using the independent samples t-test. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test when appropriate.

During the study period, a total of 315 patients presented with lower extremity injuries. Of these, 200 patients required soft tissue reconstruction and were included in the study, representing 63.4% (200/315) of all lower extremity trauma cases.

Demographic Characteristics

The study population was relatively young, with a mean age of 27.8 ± 8.6 years (range: 18–56 years), indicating a predominance of patients within the young adult age group.

With regard to sex distribution, the majority of patients were male (n = 187; 93.5%), while females accounted for only 13 patients (6.5%), yielding a male-to-female ratio of 8.5:1. This distribution reflects the increased vulnerability of young males to traumatic injuries in conflict settings. All patients were residents of Taiz city and comprised both military personnel and civilians. Soldiers constituted the majority of cases (n = 162; 81%), whereas civilians accounted for 38 patients (19%). These demographic characteristics are summarized in Table 1.

Table 1.
Demographic and baseline Characteristics of Patients (n=200)

Variable	n (%)	Mean ± SD/ rang
SEX		
Male	**187 (93.5)**	
Female	**13 (6.5)**	
AGE (year)		**27.8 ± 8.6 (18–56)**
OCCUPATION		
Solider	**162 (81%)**	
Civilian	**38 (19%)**	
RESIDANT		
Taiz city	**154 (77%)**	
Outside Taiz city	**46 (23%)**	

Anatomical site, mechanism, and reconstructive type of injuries

The leg was the most frequently affected anatomical site (n = 143), followed by the ankle (n = 40) and the knee (n = 17). Among leg injuries (n = 143;71.5%), the lower third was the most commonly involved region (n = 60; 30%), followed by the middle third (n = 52; 26%) and the upper third (n = 31; 15.5%). In approximately 10% of cases, more than one anatomical region of the limb was involved.

The mechanisms of injury affecting the leg, knee, and ankle are presented in Table 2. High-velocity projectile injuries were the most common cause of trauma (n = 123; 61.5%), followed by low-velocity gunshot injuries (n = 38; 19%), mine explosions (n = 27; 13.5%), and fragmentation (shrapnel) injuries (n = 12; 6%). Additionally, 31 patients (15.5%) developed soft tissue defects secondary to postoperative complications, including infection, wound dehiscence, or osteomyelitis.

Primary wound closure was feasible in 12 cases (6%), fig.1. The majority of wounds were managed using split-thickness skin grafts (STSGs), fig.2, which were performed in 108 patients (54%), while flap reconstruction was required in 80 patients (40%), fig.3. No free flap procedures were performed during the study period due to limited microsurgical capacity.

Anatomical site, mechanism, and reconstructive type of injuries are presented in Table 2.

Table 2.

Anatomical site, mechanism, reconstructive type of injuries and complications

Anatomical site N (%)	Mechanism of injury (n %)	Reconstruction type (n%)	Complications (n%)
Leg total 143 (71.5%)	High-velocity projectile 123 (61.5	STSG 108 (54)	Partial graft loss 4 (2%)
Leg upper third 31 (15.5%)	Low-velocity gunshot n (%) 38 (19)	fasciocutaneous flaps 27 (13.5)	Complete graft failure 1(0.5)
Leg middle third 52 (26%)	Mine/explosive 27 (13.5)	Muscle flap 53 (26.5)	Marginal flap necrosis 6(3)
Leg lower third 60 (30%)	Fragmentation 12 (6)	Primary closure	infection 3 (1.5)
Ankle 40 (20%)	Postoperative soft tissue defects 31(15.5)	12 (6)	Necrosis along suture line 2 (1)
Knee 17 (8.5%)			
Multiple regions involved 20 (10%)			

Timing of reconstruction, Hospital Stay, and Follow-Up

The timing of reconstruction was identified as the most important factor influencing the length of hospitalization.

Group I (Immediate reconstruction): 70 patients (30%), Early (<72h),and mean hospital stay of 14 days.

Group II (Delayed reconstruction): 140 patients (70%), Delayed (≥72h, mean hospital stay of 32 days.The mean duration of hospital stay in the cohort was 19.09

The duration of hospital stay ranged from 3 to 60 days, with an overall mean of 25.13 days. The follow-up period ranged from 5 to 12 months, with a mean duration of 8.9 months. Timing of reconstruction and outcome are described in table 3

Table 3.

Timing of Reconstruction and Outcomes

Outcome	Early (<72h)	Delayed (≥72h)	Effect Size 95% CI	95% CI	P value
Hospital Stay	14 ± 4	32 ± 8	MD = 18.0	20.1 to 15.8	< 0.001
Osteomyelitis	2 (3.3%)	17(12.1%)	RR =3.67	1.12–12.0	0.031

Delayed reconstruction was associated with a significant increase in hospital stay and a 3.7-fold higher risk of osteomyelitis, as well as a 2.3-fold increase in overall complications.

Local complications following reconstruction were relatively uncommon. Partial graft loss occurred in 4 patients (2%), while complete graft failure was observed in 1 patient (0.5%). Marginal flap necrosis occurred in 6 patients (3%), wound infection in 3 patients (1.5%), and necrosis along the suture line in 2 patients (1%). These complications are summarized in Table 3

Table 4.

Anatomical Location and outcome (Osteomyelitis)

Location	Osteomyelitis n (%)	RR	95% CI	
Upper third	2 (6.4%)	Reference		
Middle third	4 (7.7%)	1.20	0.25–5.68	
Lower third	11 (18.3%)	2.86	1.03–7.94	0.022

Injuries involving the distal (lower third) leg were associated with a significantly higher risk of osteomyelitis.

Discussion

War-related trauma remains a major global public health concern and has historically affected both military personnel and civilian populations. Injuries sustained during armed conflict are frequently severe and complex, often resulting from high-energy mechanisms such as explosions, gunshot wounds, and fragmentation injuries. These mechanisms commonly lead to extensive soft-tissue destruction, wound contamination, and associated skeletal injuries, thereby making clinical management particularly challenging.

Reconstruction of the lower extremity following combat-related trauma poses markedly greater challenges for reconstructive surgeons than injuries typically encountered in civilian practice, particularly within conflict-affected, resource-constrained settings. Important differences exist in the epidemiology of injury, mechanisms of trauma, wound characteristics, pathophysiological response, and clinical outcomes (7,8). War-related injuries are frequently characterized by extensive tissue loss, delayed presentation, and high rates of contamination, all of which complicate reconstructive planning and increase the risk of postoperative complications (9-11).

Over the past century, pioneers in plastic and reconstructive surgery—including Sir Harold Gillies, Varaztad Kazanjian, Archibald McIndoe, Bradford Cannon, James Barrett Brown, and Sterling Bunnell—have played a pivotal role in advancing reconstructive techniques for the management of complex traumatic injuries involving the face, hands, and extremities. Their contributions significantly shaped modern reconstructive principles and surgical approaches. Furthermore, the widespread introduction of antibiotics during World War II markedly reduced infection-related mortality among trauma patients and substantially improved outcomes in reconstructive surgery (12,13,14).

Optimal management of complex lower extremity wounds in conflict zones requires a multidisciplinary orthoplastic approach, integrating orthopedic fixation and advanced soft tissue reconstruction techniques (1). The reconstructive ladder and cascade emphasize the initial use of local and regional tissue coverage when feasible, progressing to advanced free tissue transfer and combined orthopedic-plastic techniques when required (15). Multidisciplinary coordination among orthopedic, plastic, and vascular surgeons aims to restore limb function, preserve limb length where possible, reduce disability, and improve long-term outcomes for injured patients in austere settings (1,2,).

The extremities represent the most commonly injured anatomical region in modern warfare, accounting for approximately one-third of all combat-related injuries. Other frequently affected regions include the head and neck (approximately 26%), the thorax (16–18%), the abdomen and pelvis (10–17%), and burn injuries (around 16%), which often result from explosions or chemical exposure. Spinal injuries are relatively less common (approximately 4%) but may lead to severe long-term disability (16,17,18).

During the study period, 200 patients underwent reconstructive procedures for traumatic lower extremity injuries in the Plastic and Burn Units of Al-Thawra Hospital. Injuries involving the leg, knee, and ankle accounted for 63.4% of all lower extremity trauma cases requiring reconstructive intervention. This finding is consistent with previous studies conducted in conflict settings. For example, Yassin et al. (19) reported that lower limb injuries occur more frequently than upper limb injuries in conflict environments, particularly when both civilian and military populations are

included. Similarly, Connolly et al. (20) demonstrated that lower extremity trauma represents a substantial proportion of combat-related injuries requiring reconstructive management.

In the present study, traumatic defects involving the leg, knee, and ankle were markedly more common among male patients. Males accounted for 93.5% of cases, whereas females represented only 6.5%, resulting in a male-to-female ratio of 8.5:1. This pattern reflects the demographic vulnerability of young males in conflict zones, as they are more likely to be actively involved in combat activities or exposed to hazardous environments. Additionally, the relatively low mean age (27.8 ± 8.6 years) reflects a predominantly young patient population, which is consistent with the epidemiological patterns of trauma in conflict settings, where young adults represent the most affected demographic. Similar findings have been reported in several previous studies, including those conducted by Ali reports from other conflict-affected regions (6,21-24).

The fundamental principle of soft-tissue reconstruction involves replacing missing tissue with tissue that closely resembles the original in terms of thickness, vascularity, and functional characteristics. This principle remains particularly important in lower extremity reconstruction, where adequate soft-tissue coverage is essential to protect underlying structures such as bone, tendons, and neurovascular bundles, while also restoring limb function (9,25,26).

In the present study, primary closure was feasible in only 6% of wounds, reflecting the severity and extent of tissue loss associated with war-related injuries. The majority of defects were reconstructed using split-thickness skin grafts (54%), while flap coverage was required in 40% of cases. Combination reconstructive techniques were utilized in 13.5% of cases. These findings are comparable to those reported by Sachdev et al., who also observed a high reliance on skin grafting and regional flaps in the reconstruction of traumatic lower limb defects (27). Skin grafting was the most frequently employed reconstructive technique in this series, either as definitive wound coverage or for management of donor sites. Similar trends have been reported in studies conducted in other resource-limited environments. For instance, a study from Sudan demonstrated that skin grafts were used as the primary reconstructive method in approximately 20% of patients, while combined reconstructive approaches were employed in 40.5% of cases (19). The effectiveness of local

pedicled flaps in conflict settings—particularly in resource-constrained environments—has been well documented in several reports from countries affected by armed conflict, including Iraq, Chad, Afghanistan, and Mali (28,29). These flaps provide reliable soft-tissue coverage without requiring advanced microsurgical infrastructure.

In Taiz, even prior to the onset of the current conflict, microsurgical capabilities—including free tissue transfer—were largely unfeasible due to significant resource constraints. Consequently, reconstructive strategies have predominantly relied on pedicled fasciocutaneous and muscle flaps for the management of complex soft tissue defects. In the present study, reconstruction was primarily performed using local fasciocutaneous flaps. Among these, the reverse sural artery flap remains the most frequently utilized technique, owing to its reliability and versatility in the reconstruction of distal extremity defects (19).

The timing of reconstruction represents a critical determinant of clinical outcomes in lower extremity trauma, with early intervention consistently associated with improved results and reduced complication rates 25. In the present study, a substantial proportion of patients underwent delayed reconstruction due to logistical constraints and delayed referral from peripheral healthcare facilities lacking reconstructive capabilities, a pattern similarly observed in conflict-affected and resource-limited settings (30-32).

Previous studies have demonstrated acceptable infection rates and low flap failure rates even when reconstruction is performed during the subacute period (one week to three months) following injury (33).

Understanding the biological phases of wound healing—including inflammation, granulation tissue formation, and scar maturation—helps surgeons determine the optimal timing for reconstruction and improve the likelihood of successful flap integration (34).

In this study, 60 patients (30%) underwent early reconstruction within 72 hours of injury, whereas 140 patients (70%) underwent delayed reconstruction within 14 days. Early reconstruction (<72h) reduces osteomyelitis and hospital stay, consistent with Godina (35) ($p < 0.001$), and recent evidence extending safe reconstruction window to 10 days. In contrast, delayed reconstruction was associated with a higher incidence of

osteomyelitis, particularly in cases involving exposed bone ($p = 0.006$). These findings highlight the importance of timely soft-tissue coverage in preventing deep infections and reducing overall morbidity. Early reconstruction within the first 72 hours has been widely advocated in the literature. Godina's landmark study in 1986 recommended early soft-tissue coverage within the first three days following injury to minimize infection rates and improve flap survival. More recent studies present compelling evidence supporting extension of the orthoplastic reconstruction window to up to 10 days without compromising outcomes. For example, Lee, Stranix, and colleagues demonstrated that reconstruction performed within ten days after injury was associated with significantly lower flap failure rates compared with procedures performed after this period (36).

According to Bhandari et al., the optimal timing for reconstruction of war-related wounds is typically four to five days after the final debridement, which is associated with lower complication rates and shorter hospitalization (37). However, experiences from the Iraq conflict have demonstrated that reconstruction can still achieve acceptable outcomes when performed during the subacute period (seven days to three months) following injury (33,38).

When planning reconstruction for war-related injuries—particularly in patients with multiple associated injuries—the simplest and most reliable reconstructive option should generally be preferred. In recent years, several institutions managing complex lower extremity trauma have reported successful outcomes when reconstruction was performed within 7–90 days after injury, provided that adequate wound preparation and serial debridement were performed (39,40). In such cases, vacuum-assisted closure therapy may help optimize the wound bed prior to definitive reconstruction. This finding is consistent with reports by Othman et al. and Trentz et al (41).

The rate of postoperative complications in this study was relatively low. Reported complications included partial graft loss (2%), complete graft loss (0.5%), marginal flap necrosis (3%), and wound infection (1.5%). Most complications were successfully managed through surgical debridement, secondary skin grafting, flap revision, or conservative wound care. Comparable complication rates have been reported in previous studies evaluating lower extremity reconstruction in conflict settings (42).

The mean duration of hospital stay in this study was 19.09 days, with most patients discharged within one to three weeks. Similar findings were reported by Fiona et al. and Sachdev et al., who documented a mean hospital stay of 17.82 ± 10.95 days (27 43). In another study, the median hospital stay was 19 days, and approximately 69% of patients required at least one surgical procedure (44). Likewise, Youssef Saleh et al. reported a mean hospital stay of 19.42 days for early reconstruction cases compared with 34 days for delayed reconstruction cases (45). These findings further emphasize the benefits of early reconstructive intervention in reducing hospitalization and improving overall patient outcomes.

Practical Implications in Resource-Limited Settings

In the absence of microsurgical infrastructure, the reconstructive ladder must be adapted to prioritize reliability, simplicity, and reproducibility. The present study demonstrates that acceptable outcomes can be achieved using STSGs and local flaps, even in complex war-related injuries.

Techniques such as the reverse sural flap remain indispensable in these environments due to their versatility and minimal resource requirements [16]. Additionally, staged reconstruction and adjunctive therapies (e.g., negative pressure wound therapy) may further optimize outcomes when early definitive coverage is not feasible [17].

Limitations

This study has several limitations. First, it represents a single-center experience, which may limit generalizability. Second, the absence of microsurgical reconstruction restricts comparison with free flap outcomes. Third, some variables (e.g., functional scoring systems and quality-of-life measures) were not quantitatively assessed.

Nevertheless, the prospective design, relatively large sample size, and standardized data collection strengthen the validity of the findings.

Conclusion

Lower extremity reconstruction in conflict settings is characterized by high-energy injuries, delayed presentation, and limited resources. Within these constraints, adherence to orthoplastic principles—particularly early debridement and timely soft tissue coverage—remains the cornerstone of successful outcomes.

Early reconstruction is associated with reduced hospital stay and lower rates of osteomyelitis, reinforcing its role as a key determinant of limb salvage. Where microsurgical options are unavailable, pedicled flaps and skin grafting provide reliable and effective alternatives.

Pedicled fasciocutaneous and muscle flaps, including reverse sural flaps, provided reliable coverage in the distal lower extremity [11,20,22,24]. These findings emphasize that even without microsurgical capacity, limb salvage and acceptable outcomes are achievable when orthoplastic principles are followed.

References

[1] Lin CH, Chou YC, Hsu CC, Huang RW, Lin CH. Orthoplastic approach to extremity reconstruction: a paradigm shift in integrated limb salvage. Plast Reconstr Surg. 2025; 39(3): 129-139. doi:10.1055/s-0045-1810090. PMID:40786024. (pubmed.ncbi.nlm.nih.gov).

[2] Boos AM, Delbrück H, Lichte P, Schäfer B, Gombert A, Uhl C, et al. Orthoplastic surgery for interdisciplinary extremity reconstruction. Int J Surg Sci. 2025;11(1):3-13. (pmc.ncbi.nlm.nih.gov)

[3]World Health Organization Eastern Mediterranean Region. Multiple fractures after an explosive injury in Gaza. East Mediterr Health J. 2025;31(4):—. (emro.who.int) Trauma patterns in Gaza during armed conflict: survey study of international healthcare workers. BMJ Mil Health. 2025; 483(11): 2047-2055. doi:10.1097/CORR.0000000000003618. (pubmed.ncbi.nlm.nih.gov)

[4] Srivastava K, Ibrahim A, Qandeel M, et al. Role of combined ortho-plastic approaches in the reconstruction of Gustilo–Anderson Grade III upper limb injuries: a systematic review.

[5] Wild H, Stewart BT, LeBoa C, Stave CD, Wren SM. Epidemiology of injuries sustained by civilians and local combatants in contemporary armed conflict: an appeal for a shared trauma registry among humanitarian actors. World J Surg. 2020 Jun;44(6):1863-1873. doi: 10.1007/s00268-020-05428-y.

[6] Hannah Wild et al. Epidemiology of Injuries Sustained by Civilians and Local Combatants in Contemporary Armed Conflict: An Appeal for a Shared Trauma Registry Among Humanitarian Actors. World J Surg (2020) 44:1863–1873.

[7] Geiger S, McCormick F, Chou R, Wandel AG. War wounds: lessons learned from Operation Iraqi Freedom. Plast Reconstr Surg. 2008;122(1):146–53.

[8] Kumar AR. Standard wound coverage techniques for extremity war injury. J Am Acad Orthop Surg. 2006; 14(10 Spec No): S62–5.

[9] Soltanian H, Garcia RM, Hollenbeck ST. Current concepts in lower extremity reconstruction. Plast Reconstr Surg. 2015;136(6):815e–829e.

[10] Godina M. Early microsurgical reconstruction of complex trauma of the extremities. Plast Reconstr Surg. 1986; 78(3): 285–292.

[11] Masquelet AC, Gilbert A. Atlas of Musculocutaneous Flaps of the Limbs. New York: Springer; 1992.

[12] Baumeister S, et al. Reverse sural artery flap for distal leg reconstruction. J Plast Reconstr Aesthet Surg. 2003;56:149–158.

[13] Whitaker IS, et al. The birth of plastic surgery during World War I. J Plast Reconstr Aesthet Surg. 2007; 60:1–7.

[14] Holcomb JB, Stansbury LG, Champion HR, Wade C, Bellamy RF (2006) Understanding combat casualty care statistics. J Trauma 60(2):397–401. https://doi.org/10.1097/01.

[15] Levin LS. The reconstructive ladder. An orthoplastic approach. Orthop Clin North Am 1993; 24 (03) 393-409.

[16] Gillies HD, Millard DR. The Principles and Art of Plastic Surgery. London: Churchill Livingstone; 1957.

[17] Owens BD, et al. Combat wounds in Operation Iraqi Freedom and Operation Enduring Freedom. J Trauma. 2008;64(2 Suppl):S239–S247.

[18] Chevalley K, Zimmerman J, Mittendorf A, Sennersten F, Dalman A, Frogh S, et al. Civilian pattern of injuries in armed conflicts–a systematic review. Scand J Trauma Resusc Emerg Med. 2024; 32(1): 1–9.

[19] Yassin AM, Mohamed M, Dirar M, Karar I, Ali M, Ahmed M, et al. The portrayal of injuries to the extremities and their reconstruction in times of conflict (Khartoum, Sudan): a crosssectional study. Ann Med Surg. 2025; 87(3): 1181–9. 15.

[20] Connolly M, Ibrahim ZR, Johnson ON. Changing paradigms in lower extremity reconstruction in war-related injuries. Mil Med Res. 2016;3:1–6.

[21] Ahmed et al. Plastic surgery interventions for war-related injuries: a review of 300 cases from Sudan, a cohort study. BMC Surgery (2025) 25: 442.

[22] Adam Stepniewski1 & Dominik Saul2 & Helen Synn3 & Gunther Felmerer1 Eur J Plast Surg (2020) 43:425–434 18.

[23] Suri MP, Patel AG, Vora HJ, Raibagkar SC, Mehta DR, Vyas VH. Post traumatic posterior heel soft tissue defect reconstruction. Indian Journal of Plastic Surgery.

[24] Akhtar S, Hameed A, Versatility of the sural fasciocutaneous flap in the coverage of lower third leg and hind foot defects. Plast. Reconstr. Aesthet Surg. 2006; 59(8); 839 – 45, e-pub 2006, Mar. 9.

[25] Mendenhall SD, Ben-Amotz O, Gandhi RA, et al. A Review on the Orthoplastic Approach to Lower Limb Reconstruction. Indian J Plast Surg 2019; 52(1): 17–25.

[26] Heller L, Levin LS. Lower extremity microsurgical reconstruction. Plast Reconstr Surg 2001; 108(4): 1029–41 [quiz: 1042].

[27] Sachdev S, et al. Reconstruction of war-related lower limb injuries. J Plast Reconstr Aesthet Surg. 2019; 72: 1343–1352.

[28] Brown KV, Roberts DC, Wordsworth M, Duraku LS, Jose RM, Power DM, et al. Management of conflict injuries to the upper limb. Part 1: assessment and early surgical care. J Hand Surg (European volume). 2022; 47(7): 68797.

[29] Mathieu L, Plang S, de l'Escalopier N, Murison JC, Gaillard C, Bertani A, et al. Soft tissue coverage using pedicled flap in combat zone: a case series. Military Med Res. 2020; 7:1–7

[30] Xiong L, Gazyakan E, Kremer T, et al. Free flaps for reconstruction of soft tissue defects in lower extremity: a metaanalysis on microsurgical outcome and safety. Microsurgery 2016; 36: 511-24. DOI PubMed.

[31] Pederson WC, Grome L. Microsurgical reconstruction of the lower extremity. Semin Plast Surg 2019; 33: 548. DOI PubMed PMC.

[32] Lerman OZ, Kovach SJ, Levin LS. The respective roles of plastic and orthopedic surgery in limb salvage. Plast Reconstr Surg 2011; 127 Suppl 1:215S27S. DOI PubMed.

[33] Tintle SM, Gwinn DE, Andersen RC, Kumar AR. Soft tissue coverage of combat wounds. J Surg Orthop Adv 2010;19:29-34.

[34] McCraw JBAPG. McCraw and Arnold's atlas of muscle and musculocutaneous flaps. Norfolk (VA): Hampton Press Pub. Co; 1988.

[35] Godina M.: Early microsurgical reconstruction of complex trauma of the extremities. Plast. Reconstr. Surg., 78: 285- 292, 1986.

[36] Lee C, Stranix JT, et al. Optimal timing of microsurgical reconstruction in lower extremity trauma. Plast Reconstr Surg. 2020;145:122–131

[37] Bhandari M, et al. Timing of reconstruction in war wounds: systematic review. J Trauma Acute Care Surg. 2017; 83: 1243–1250.

[38] Kumar AR, Grewal NS, Chung TL, Bradley JP. Lessons from operation Iraqi freedom: Successful subacute reconstruction of complex lower extremity battle injuries. Plast Reconstr Surg 2009; 123: 218-29.

[39] Zaki M.S., Aly Y.A., El-Sharkawy A.G. and El-Faramawy A.A.: Anatomical grounds of the inferiorly based gastrocnemius muscle flap. Egyptian Journal of Plastic and Reconstructive Surgery, 15 (1): 8-12, 1991.

[40] Cohen B.E. and Ciaravino M.E.: Gastrocnemius muscle and musculocutaneous flaps. Quoted from “Grabb’s encyclopedia of flaps”, 2nd ed., 1998.

[41] Othman S, Stranix JT, Piwnica-Worms W, et al. Microvascular free tissue transfer for reconstruction of complex lower extremity trauma: Predictors of complications and flap failure. Microsurgery 2021. DOI PubMed.

[42] Franken JM, Hupkens P, Spauwen HM. The treatment of soft-tissue defects of the lower leg after a traumatic open tibial fracture. Eur J Plast Surg. 2010; 33: 129-33.

[43] Fiona R, et al. Hospital stay and outcomes after lower limb reconstruction. Injury. 2018; 49: 2563–2570.

[44] Christensen MC, Ridley S, Lecky FE, Munro V, Morris S. Outcomes and costs of blunt trauma in England and Wales. Critical care. 2008; 12(1): R23.

[45] Saleh Y, Waheeb B, Abd-Elaziz MA, El-Oteify M. A Suggested Algorithm for Post-Traumatic Lower Limb Soft Tissue Reconstruction. Egypt J Plast Reconstr Surg. 2007; 31(1): 87-96.