

Research Article

Salvage of Mangled Lower Extremity – Single Institution Experience

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Abstract

Background: Treatment of severe limb injuries remains controversial. Modern advances in resuscitation, free tissue transplantation, and fracture fixation have made these limbs salvageable although this is difficult and time-consuming. Various scoring systems have been proposed to predict the outcomes.

Objective: To describe our experience in salvaging mangled lower extremities at a tertiary care hospital. This Retrospective Cohort Study was conducted at the Department of Plastic Surgery Shifa International Hospital Islamabad Pakistan, from January, 2013 to December, 2022.

Methodology: All patients of either gender with the age range of 16 to 70 years, with mangled lower extremity who underwent limb salvage surgery, were included in this study. Radiological assessments were done preoperatively using X-rays, CT scans, and angiograms if indicated. These patients were assessed using The Mangled Extremity Severity Score (MESS) to assess their eligibility for salvage. A maximum score of 15 was summed. A score of < 7 was used as predictive of salvage.

Results: A total of 60 patients underwent limb salvage during this 10 year period. A significant proportion of mangled lower extremities were successfully salvaged (78.3%), while 21.7% required subsequent amputation. In terms of the mechanism of injury, 60% of cases were attributed to Road Traffic Accidents (RTA), 18.3% to Falls, 15% to Gun Shots, and 6.7% to Bomb Blast. From the pedicled flaps group, the gastrocnemius was performed in most cases, comprising 15% of total reconstruction, followed by soleus (10%). Free Latissimus Dorsi (LD) flap was used as free tissue transfer in 21%, followed by Free Anterolateral thigh (ALT) flap (10%).

Conclusion: The overall salvage rate for mangled lower extremities in the study was 78.3%. This suggests that irrespective of gender or mechanism of injury, salvage procedures were generally successful in a significant majority of cases.

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Introduction

The definition of mangled extremity is an upper or lower limb with an injury to at least three out of four cardinal structures (soft tissue, bone, nerves and vessels).¹ In the past mangled extremities were associated with a high rate of amputation. However recent advancements in resuscitation, fractured bone fixation and microvascular tissue transfer have made it possible to salvage the critical limb.² data show that amputation

rate for mangled extremities has reduced from 72 to less than 10%.³ Despite modern advancements, the management of mangled extremities is a challenging choice for the patient and the involved surgical team. Appreciation of the various factors in decision-making, potential risk factors, available reconstructive options and their functional outcomes are essential to positive patient outcomes.⁴

Blunt trauma is the most common mechanism of injury

for patients who present with a mangled extremity. In the civilian population significant number of these presentations are caused by Road Traffic Accidents, industrial accidents, falls, gunshots, and explosive injuries.⁵ The most important factor is the amount of energy transmitted to the limb not the mechanism of injury. A meta-analysis concluded that lower limb salvage is more desirable than amputation psychologically to patients with mangled lower extremities.

Multiple scoring systems have been suggested in the past to help in the decision-making process of these complex extremity traumas. 1990 Johansen et al. introduced The Mangled Extremity Severity Score (MESS)⁷. Four distinct factors are scored; skeletal and soft tissue injury, shock, patient age and ischemia with a maximum score of 15. A score below 7 indicates a better prognosis and a score above 7 indicates a higher risk of amputation.^{8,9}

This study aimed to identify the problem and gap in knowledge by fostering a holistic understanding of the challenges and opportunities associated with limb salvage to contribute to the ongoing evolution of best practices in the field in our local population, ultimately enhancing patient outcomes and facilitating a higher standard of care for those affected by these traumatic injuries in our local population.

Methodology

This descriptive study was carried out in the Department of Plastic Surgery at Shifa International Hospital Islamabad Pakistan, from January 2013 to December 2022. Ethical approval (Ref No: IRB# 011-24) was acquired from the Institutional Ethical Committee. The study population was gathered by nonprobability, consecutive technique. A P-value of <0.05 was taken as a statistically significant finding. Patients with mangled lower extremities who underwent limb salvage surgery were included. Patients with concomitant life-threatening injuries were excluded.

All selected patients were asked for written informed consent regarding their data utilization. Initial clinical findings along with the Radiological findings including preoperative imaging such as X-rays, CT scans, and angiograms were noted. The extent of soft tissue damage, vascular compromise, and bone injuries were documented which aided in surgical planning and decision-making. All patients were assessed using the Mangled Extremity Severity Score (MESS), patient who had a score of < 7 were planned for limb salvage. After that

salvage procedures were carried out, including the surgeries for involved structures (e.g., debridement, vascular repair, bone fixation, soft tissue reconstruction). Surgical time, blood loss, and intraoperative complications (if any) were documented.

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) version 23.0. Mean + SD was obtained for quantitative variables. Qualitative variables were recorded as frequencies and percentages. The chi-square test was applied keeping a p-value < 0.05 as the significance level.

Results

A total of sixty patients underwent limb salvage in this duration. The mean age was 34.87+16.381 years. The mean MESS Score was 6.70+1.934. The study population predominantly consisted of males, comprising 71.7%, while females constituted 28.3%. In terms of the mechanism of injury, 60% of cases were attributed to Road Traffic Accidents (RTA), 18.3% to Falls, 15% to Gun Shots, and 6.7% to Bomb Blast. Surgical interventions encompassed debridement and wound closure and/or skin grafting in 21.7%. Soft Tissue Reconstruction with Local or free flap in 78.3%. A significant proportion of mangled lower extremities were successfully salvaged, with 78.3%, while 21.7% required amputation. (Table-1).

From the pedicled flaps group, the gastrocnemius was performed in the majority of cases, comprising 15%

Table 1: Demographic and Clinical characteristics of patients (n=60)

Quantitative Variables	Mean+SD
Age (Years)	34.87±16.381 Years
MESS Score	6.70±1.934 Score
Qualitative Variables	
Gender, n (%)	
Male	43 (71.7%)
Female	17 (28.3%)
Mechanism of Injury, n (%)	
RTA	36 (60.0%)
Fall	11(18.3%)
Gun Shots	9 (15.0%)
Bomb Blast	4 (6.7%)
Type of Surgery, n (%)	
Debridement and closure or STSG	13 (21.7%)
Soft tissue Reconstruction	47 (78.3%)
Mangled Lower Extremity Salvaged, n (%)	
Yes	47 (78.3%)
No	13 (21.7%)

of total reconstruction, followed by soleus (10%). Free Latissimus Dorsi (LD) flap was used as free tissue transfer in 21%, followed by Free Anterolateral thigh (ALT) flap (10%). (Table- 2)

Table 2: Types of Soft Tissue Flap Reconstruction

Type of Flap	n (%)
Gastrocnemius	9 (15%)
Soleus	6 (10%)
Propeller Flap	4 (6%)
Sural Flap	3 (5%)
Other Local Flaps	6 (10%)
Free LD Flap	13 (21%)
Free ALT Flap	6 (10%)
No Flap required	13 (21.7%)

Our study explored the relationship between the mechanism of injury and the success of mangled lower extremity salvage procedures. The distribution of mechanisms of injury included RTA, Fall, Gun Shot, and Bomb Blasts. The salvage rates varied slightly across different mechanisms of injury. Sixty-six percent of the mangled lower extremity from RTA, 14.9% from fall, 12.8% from Gun Shots and 6.4% from Bomb Blast were recorded. (Table-3) However, the p-value of 0.33 suggests that these observed differences in salvage rates among different mechanisms of injury are not statistically significant. Therefore, based on the available data, there is no strong evidence to suggest a significant association between the mechanism of injury and the outcome of mangled lower extremity salvage procedures.

Our study noted the relationship between gender and the success of mangled lower extremity salvage procedures. The majority of participants were male (73.3%), and the overall salvage rate was 78.3%. The analysis by gender revealed that 81.4% of mangled lower extremities were salvaged in males, and 70.6% were salvaged in females. However, the p-value of 0.360 indicates that this observed difference in salvage rates between genders is not statistically significant. Therefore, based on the available data, there is no strong evidence to suggest a

significant association between gender and the outcome of mangled lower extremity salvage procedures. (Table-4).

Table 4: Association of Mangled Lower Extremity Salvaged with Gender (n=60)

		Gender		Total	p-value
		Male	Female		
Mangled Lower Extremity Salvaged	Yes	35	12	47	0.360
		81.41%	70.6%	78.3%	
No	8	5	13		
	18.6%	29.4%	21.7%		
Total		43	17	60	
		100.0%	100.0%	100.0%	

Discussion

High-energy open fractures from RTA, falls, Gun Shots, bomb blasts and crush injuries to the lower limbs presenting in the trauma room, the clinical decision to either attempt limb salvage or to proceed with a primary amputation, are common challenges to trauma surgeons.¹⁰ The first step in the management of severely injured limbs starts with resuscitation and stabilization of the patient following the ATLS protocols and addressing any life-threatening injuries.

On the Trauma Call, our Trauma Team of an Orthopedic Surgeon, a Plastic Surgeon and a Vascular Surgeon is mobilized to receive the patient in the resuscitation area. A team approach in the early presentation of the patient and decision-making for life over a limb and possibly functional outcome of the mangled lower extremity is recommended.¹¹

It was presented in a previous study that early debridement of devitalized tissue is a vital part of the management of the mangled lower extremity in reducing the risk of infection and tissue hypoxia.¹² A second and third look debridement was carried out if required, before proceeding for the definitive wound closure. All necrotic muscles were excised adequately as it can risk a patient’s life shortly if left intact.¹³

Timing of the wound closure or reconstruction is very

Table 3: Association of Mangled Lower Extremity Salvaged with Mechanism of Injury (n=60)

			Mechanism of Injury				Total	p-Value
			RTA	fall	Gun Shots	Bomb Blast		
Mangled Lower Extremity Salvaged	Yes	Count	31	7	6	3	47	0.330
		% within Mangled Lower Extremity Salvaged	86.1	63.6	66.7	75.0	78.3	
No	Count (n)	5	4	3	1	13		
	% within Mangled Lower Extremity Salvaged	13.9%	36.3%	33.3%	25.0%	21.7%		
Total		Count	36	11	9	4	60	
	% within Mangled Lower Extremity Salvaged	60.0%	18.3%	15.0%	6.7%	100.0%		

important. Our patients underwent definitive closure between 7 to 10 days. Godina¹⁴ favored the early wound closure with a well-vascularized tissue in 1986. Byrd et al.¹⁵ reconstructed open tibial fractures with muscle flaps in the first five days. Another study¹⁶ was conducted in 2018 favoring Godina's Principles of early reconstruction of the lower limb.

In our study, almost all patients underwent Vacuum Assisted Closure (VAC) therapy before the definitive procedure as DeFranzo et al.¹⁷ has demonstrated VAC in lower extremity injuries. It promotes the formation of granulation tissue and increases blood flow to the injury site.¹⁷

For definitive reconstruction, the Gastrocnemius muscle was the most common flap for lower limb reconstruction in our study and Soleus was used mainly for proximal and middle thirds of the leg wounds, study by AlMugaren et al¹⁸ has described the same findings. Propeller flaps were used for small to moderate size soft tissue defects in the lower limb.¹⁹ Free flaps were designed for distal and large-size defects. LD muscle or fasciocutaneous free flap was suitable for large defects as it has the advantage of its long-size pedicle. Other common free flaps available for lower extremity reconstruction are ALT Flap, Rectus Abdominus Flap, Radial Forearm Flap, and Gracilis Flap.

We have learned from our experience that free LD muscle flap atrophies with time matching the contour although it looks bulky at the immediate post-op period. In our study 13 (21%) Free LD muscle flaps were employed that resulting in an excellent contour match. Osteomyelitis is a common complication for open fractures and early reconstruction of the defect with a muscle flap decreases the risk of developing this unsettling complication.²⁰

In cases of mangled lower extremities, a meta-analysis comparing amputation with limb salvage revealed that patients with limb salvage did better psychologically than amputees, but there was no difference in biological outcomes.²¹ After two and seven-year follow-ups, the Lower Extremity Assessment Project (LEAP) study showed no difference in functional outcomes between limb salvage and amputation patients.²² The Military Extremity Trauma Amputation/Limb Salvage (METALS) study contradicts from LEAP study. It included 324 service members who had lower limb injuries and were either amputated or had their limbs salvaged. It was a retrospective cohort study. Amputees in this study not

only performed better on functional assessments, but they were also able to engage in more strenuous physical activity than those who received limb salvage.²³

However, amputations are major life-altering operations that necessitate substantial functional adaptations on the part of the patient. Consequently, it is critical to use a multidisciplinary approach that takes these factors into account when determining surgical treatment options for patients with complicated limb injuries. From the very beginning, the patient should be included in making therapeutic decisions, and their desires should always be honored by the management team.

It is essential to acknowledge the potential limitations of this single-center retrospective study such as the sample size, limited follow-ups, and any unaccounted confounding variables. A larger sample size under randomized control trials may provide more robust and generalizable findings.

Conclusion

The overall salvage rate for mangled lower extremities in the study was 78.3%. This suggests that irrespective of gender or mechanism of injury, salvage procedures were generally successful in a significant majority of cases. The study underscores the importance of a comprehensive and multidisciplinary approach to mangled lower extremity injuries. Factors beyond gender or mechanism of injury, such as individual patient characteristics, may play crucial roles in determining salvage success.

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Author's Contribution

The following authors have made significant contributions to the manuscript as under:

Dr. Shah Zaib Aslam; Conception and design of the study, data collection, analysis and interpretation

Dr. Muhammad Ibrahim Khan; Critical revision of the article and final approval of the article to be published

Dr. Adeela Hussain Khan; Critical revision of the article and final approval of the article to be published

Dr. Rashmeen Khan Afridi; Substantial contributions to the acquisition, analysis and interpretation of data

Dr. Farwa Shabbir; Substantial contribution to acquisition, analysis and interpretation of data

Dr. Mamoona Gohar; Substantial contributions to the acquisition of data, critical review

The authors undertake to take full responsibility for the work and to make sure that any concerns about the integrity or correctness of any portion of the work are duly looked into and addressed.

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