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Research Article

Combined Orthopedic and Plastic Surgical Strategies in Management of Gustilo Grade Iii Open Fractures

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ABSTRACT

Objective: To compare functional outcomes, infection rates, and limb salvage rates of integrated ortho-plastic treatment of Gustilo-Anderson Grade III open fractures in a trauma sample.

Materials and Methods: This is a prospective cohort study whereby 187 patients with Gustilo Grade III (GG-III) open fractures (III-A: n=42, III-B: n=118, III-C: n=27) were enrolled in the study to have been treated using a specific orthoplastic service in tertiary care centers in Pakistan during the period between January 2022-December 2024. The main outcomes were a deep infection rate, the time of full coverage of soft tissue, bony fusion, and the salvage of limbs. Secondary outcomes involved functional assessment by the use of Lower Extremity Functional Scale (LEFS) and Disabilities of the Arm, Shoulder and Hand (DASH) scores.

Results: The average time to conclusive soft tissue cover was 5.2 +- 2.8 days. Deep infection was registered in 14.4% of the patients (27/187) which is significantly lower than the historical controls (32.6%, p=0.001). Salvage of the limbs was done in 93.6% (175/187) of the cases. Patients who were covered within 72 hours had significantly lower infection rates (8.7% vs. 24.3%, p=0.003) and had a faster bony union (18.4 +- 4.2 vs. 24.7 +- 5.8 weeks, p<0.001). In 68.4% III-B/III-C injuries the survival rate was 94.2% by using free flaps. Multivariate regression found significant predictors of deep infection of delayed coverage (>7 days), vascular injury and diabetes (p<0.05).

Conclusion: Orthoplastic management is an important intervention in resource-limited Pakistani hospitals that enhances limb salvage and decreases deep infection in Gustilo Grade III fractures. New soft tissue coverage during the first 72 hours becomes the most significant variable that can be modified and shaped. Formation of orthoplastic teams is a cost-efficient approach to complicated limb trauma in developing countries.

Keywords: Orthoplastic Surgery, Gustilo-Anderson Classification, Open Fracture, Limb Salvage, Soft Tissue Reconstruction, Trauma Surgery.

INTRODUCTION

The traumatic open fractures constitute one of the most complicated clinical situations in orthopedic trauma surgery that requires careful management of both bony and soft tissue parts to avoid disastrous outcomes such as deep infection, nonunion, and amputation [1]. Of such injuries, GG-III fractures with large amounts of soft tissue injury, periosteal stripping, and contamination are the most morbid and offer reconstructive challenges that are difficult to overcome [2]. Such injuries have an epidemiological burden that is disproportionately high in low- and middle-income countries (LMICs), and road traffic accidents, industrial mishaps, and agricultural trauma occur frequently amid a healthcare resources shortage [3].

Pakistan represents a typical example of this global health disparity, given its fast-paced motorizing population and developing trauma infrastructure. Road traffic accidents by themselves are the cause of about 46 percent of the trauma admission in major centers in Pakistan with orthopedic injuries representing 35 percent of trauma patients [4]. Among them, open tibial fractures are the most common long bone open fractures with an

annual incidence of 3.4 per 100,000 population that prove exceptionally severe and about 45% of them are GG-III [5]. It was reported at one tertiary hospital in Lahore that more than 20,000 injuries associated with accidents were reported each year and a significant percentage of these cases involved the limbs complex damage necessitating multidisciplinary reconstructive action [6]. This is an epidemiological fact that highlights the dire need to employ the best management guidelines when working in environments with limited resources.

Traditionally, the treatment of complex open fractures was done in a sequential way: orthopedic surgeons dealt with bony stabilization and debridement, and plastic surgeons were involved when the complication had already occurred (e.g. wound breakdown or infection) [7]. Such a discontinuous strategy often led to treatment delays, reoperative procedures and poor functional performance. The paradigm shift of the integrated orthoplastic care in which orthopedic and plastic surgical teams work together since the first presentation until a final reconstruction has transformed the global limb salvage strategies [8]. This team model acknowledges that bone will not be cured unless there is sufficient soft tissue coverage and soft tissue reconstruction will not be effective unless there is stable skeletal structure [9].

The conceptual basis of the orthoplastic surgery was first developed by an early work of Godina in the 1980s, who established that primary microsurgical reconstruction in the first 72 hours of injury significantly decreased the rate of infection and enhanced rehabilitation in open tibial fractures [10]. Later experience proved that the coverage of the soft tissues (less than 7 days) at the early stage of development greatly reduces the risk of deep infections in contrast with delayed reconstruction [11]. Nevertheless, the employment of these principles to practice in LMICs has its own peculiarities: the shortage of microsurgical skills, the unavailability of the operating room time, financial difficulties with high-tech implants, and the unequal availability of specialised postoperative follow-up [12]. Although limited by these, there is emerging evidence in centers in India, Egypt and Pakistan to suggest that using modified orthoplastic protocols can deliver results comparable to those of high-income nations [13].

The pathophysiological complexity of GG-III injuries predetermines the need to consider many spheres that include violent surgical debridement of eliminating nonviable tissue and bacterial load; skeletal stabilization balancing mechanical stability and soft tissue preservation; timely soft tissue coverage to safeguard bare bone, hardware, and neurovascular bundles; and multidisciplinary antimicrobial therapy to combat polymicrobial contamination [14]. Grade III fractures are also further divided into III-A (sufficient soft tissue coverage despite massive laceration), III-B (extensive periosteal stripping necessitating flap coverage) and III-C (related arterial injury necessitating repair) [15]. The subclass III-A injuries can be treated by split-thickness skin grafts or the use of local flaps; III-B injuries usually necessitate free or pedicled muscle flaps; and III-C injuries are those that require vascular repair before or with skeletal and soft tissue repairs [16]. Skeletal stabilization in the contaminated wounds is still controversial. Although past studies have used external fixation (circular Ilizarov or monolateral frames) as the gold standard in Grade III injuries because of limited soft tissue disturbance [17], current evidence suggests early replacement with internal fixation (locked intramedullary nailing or plate osteosynthesis) in cases where the conditions of the soft tissues allow [18]. The Ilizarov technique has specific benefits in the situation in Pakistan: it is cost-effective (unlike locking plates that are costly), it can be used to treat bone defects due to the distraction osteogenesis process, and it allows treating wound care due to the flexibility of frames [19]. But long-term external fixation is associated with pin-site infections and patient discomfort, which has led to a desire to adopt early definitive internal fixation after success with soft tissue coverage [20].

Empiric therapy with vancomycin with a third-generation cephalosporin or carbapenem is currently recommended, with a maximum of 24 hours of therapy after the definitive wound closure except in case of active infection [21]. Moreover, socioeconomic issues such as patient financial capacity, transport obstacles to follow-up, and cultural preferences towards amputation vs. long-term reconstruction have a significant impact on the course of treatment that cannot be explained by Western literature [22].

This research is aimed to fill these knowledge gaps by prospectively assessing the results of

a standardized orthoplastic regimen that is applied in the three largest Pakistani trauma units. Our postulation was that the limb salvage rates would be more than 90% with a deep infection rate of less than 15% under the integrated management approach with the same resources as the international standards.

MATERIALS AND METHODS

Design of the Study and Ethics: This was a prospective and multicenter cohort study performed in three tertiary care hospitals in Pakistan. Respective Institutional Review Boards approved the study protocol and followed the principles of Declaration of Helsinki. All the participants or their legal representatives signed informed consent. The trial was enrolled to the Pakistan Clinical Trials Registry. Patient Selection and Inclusion Criteria: patients were eligible by being consecutive adult patients with acute Gustilo-Anderson Grade III open fractures of extremity upper or lower. The inclusion criteria included: (1) Gustilo Grade III-A, III-B, or III-C fracture, senior orthopedic surgeon confirmed; (2) the presentation within 24 hours of injury; (3) the ability to follow-up at least 12 months (present); (4) no previous ipsilateral limb surgery within 6 months. Exclusion criteria were; (1) pathological fracture; (2) Gustilo Grade 1 or 2 injury; (3) bilateral life threatening injury necessitating non-orthopedic emergency intervention (ISS >25); (4) patient refusal of limb salvage surgery. OrthoPlastic Service Model: Each center was assigned a designated orthoplastic unit consisting of two orthopedic trauma surgeons and two plastic/reconstructive surgeons that had undergone microsurgical training. The staff worked according to a standard protocol: First Evaluation (Emergency Department): Orthopedic and plastic surgeons evaluation within 30 minutes of the arrival. The documentation also covered the size of the wound, the type of contamination (clean, soil, water, farmyard), the status of the neurovascular, the compartment pressures, and the radiographic evaluation (AP/lateral X-rays +- CT angiography in case of suspected vascular injury). Primary Debridement (Operating Room 1): This surgery had been performed by orthopedic surgeon in 6 hours of injury and was accompanied by plastic surgeon. Required protocols: (1) elliptical wound circumcision; (2) serial debridement of contaminated wound edges (measured by contractility, color, consistency, capillary bleeding); (3) extensive irrigation with normal saline pulsed lavage; (4) removal of all foreign bodies; (5) fracture fixation of spanning of the external frame (monolateral of upper limb, Ilizarov circular frame around lower limb segmental defects); and (6) wound left open with saline-impregnated gauze or NPWT Antibiotic Protocol: Intravenous ceftriaxone 2g + vancomycin 1g started at ED and continued during 24 hours at definitive closure. To treat farm/soil contamination: metronidazole 500mg TDS was added. Adjusted antibiotics intraoperative cultures were taken and local antibiogram revealed 68% ESBL prevalence. Definitive Reconstruction (Operating Room #2): Plastic surgeon who was in charge of soft tissue coverage planning under 24 hours of index debridement. Stratification of coverage times: early (less than 72 hours), intermediate (72 hours-7 days), or delayed (greater than 7 days). Flap choice: (1) defects less than 50 cm2 with exposed bone: reverse sural artery flap (lower limb) or radial forearm flap (upper limb); (2) defects 50-150 cm2: free anterolateral thigh flap; (3) defects greater than 150 cm2 or exposed hardware: free latissimus dorsi flap or rectus abdominis flap; (4) vascular injury: Free flap+ vascularized bone graft in case of segmental defect longer than Internal fixation (intramedullary nailing of diaphyseal tibia/femur; metaphyseal injuries conversion to locking compression plate) at 7-14 days after coverage provided the patient showed no signs of infection. Persistent nonunion after 4 months bone grafting (iliac crest autograft). Data Collection and Outcome Measures: Demographic (age, gender, comorbidities), injury (mechanism, location, Gustilo subclass, Mangled Extremity Severity Score [MESS]) data, and treatment (time to debridement, coverage timing, flap type, fixation method) data were collected prospectively. Primary Outcomes: Deep infection: purulent discharge positive culture bone/deep tissue that needs surgical intervention. Limb salvage rate: no amputation at end of follow-up, Time to bony union: Radiographic commitment of 3/4 cortices. Secondary Outcomes: Functional scores: LEFS (0-80, higher=better) lower limb, DASH (0-100, lower=better) upper limb at 6 and 12 months. Flap survival rate, Reoperation rate (unintended returns to OR) Length of hospital stay. Follow-up Protocol: 2 weeks, 6 weeks, 3 months, 6 months and 12 months after the injury. A wound examination, neurovascular examination, and functional scoring were used

as clinical assessment. Radiographs at each visit until union was established. Suspected deep infection based on clinical grounds was aspirated to have culture/sensitivity. Statistical Analysis: Grunding on 32% historical deep infection rate of Grade III fracture in participating centers, sample size will be calculated. A minimum of 85 patients (a=.05, 80% power) was needed to achieve 50% relative reduction (to 16). Predicting 15% of loss to follow-up, aiming to enroll 100 patients; in actual enrolled higher since it was a multicenter study. Analysis was done in SPSS v26.0 (IBM Corp., Armonk, NY). Continuous variables mode of expression of mean +- SD, categorical variables mode of expression of frequencies/percentages. Categorical variables Student t-test (parametric) or Mann-Whitney U (non-parametric); Chi-square or Fisher exact test. Continuous variables Student t-test (parametric) or Mann-Whitney U (non-parametric). Multivariate logistic regression was used to find independent predictors of deep infection. Time-to-union Kaplan-Meier with log-rank test. The level of statistical significance of $p<0.05$.

RESULTS

Demographics and Characteristics of Injury in the Patient.

Out of 214 patients that were screened, 187 patients were included in the study (mean age 34.7 +- 12.3 years; 84.5% men). Machinery: road traffic accidents (76.5%), industrial machinery (14.4%), falls of a height (6.4%), agricultural trauma (2.7%). Distribution In the bones of the forearm, tibia (68.4%), femur (12.8%), humerus (10.2%), forearm bones (8.6%). Distribution of gustilo subclass: III-A (22.5% n=42), III-B (63.1% n=118) III-C (14.4% n=27). Mean MESS was 6.8 +- 1.9. Comorbidities health diabetes mellitus (18.7%), smoking (42.2%), malnutrition (BMI <18.5 kg/m2; 24.6%). Table 1 gives the baseline characteristics stratified by the timing of the coverage.

Table 1: Baseline Characteristics Stratified By Timing of Soft Tissue Coverage (N=187)

Variable	Early Coverage (<72h) n=69	Intermediate (72h–7d) n=78	Delayed (>7d) n=40	p-value
Age (years), mean± SD	32.4± 11.8	35.1± 12.6	37.2± 13.1	0.042
Male gender, n (%)	60 (87.0)	64 (82.1)	34 (85.0)	0.681
Diabetes, n (%)	8 (11.6)	16 (20.5)	11 (27.5)	0.038
Gustilo III-C, n (%)	6 (8.7)	12 (15.4)	9 (22.5)	0.047
Mean wound size (cm^2)	84.3± 32.7	96.8± 41.2	112.4± 48.9	0.003
Ilizarov fixation, n (%)	38 (55.1)	52 (66.7)	31 (77.5)	0.029
NPWT bridge, n (%)	12 (17.4)	34 (43.6)	28 (70.0)	<0.001

Treatment Parameters and Primary Outcomes

Mean time from injury to first debridement was 4.8± 2.1 hours. Mean time to definitive soft tissue coverage was 5.2 ± 2.8 days overall, with significant variation by subclass: III-A (2.1± 1.3 days), III-B (6.4± 2.6 days), III-C (8.9 ± 3.4 days; $p<0.001$). Coverage methods: split-thickness skin graft (15.5%), local/pedicled flap (16.0%), free flap (68.4%). Free flap types: anterolateral thigh (42.3%), latissimus dorsi (18.7%), rectus abdominis (7.4%). Flap survival rate was 94.2% (121/128) for free flaps and 96.7% (29/30) for pedicled flaps.

Deep infection developed in 27 patients (14.4%). Infection rates stratified by coverage timing: early 8.7% (6/69), intermediate 14.1% (11/78), delayed 25.0% (10/40; $p=0.003$). Limb salvage achieved in 175 patients (93.6%); 12 amputations performed (8 below-knee, 3 above-knee, 1 below-elbow) due to uncontrolled sepsis (n=7), irreversible vascular compromise (n=3), or patient request after prolonged reconstruction (n=2). Mean time to bony union was 20.3 ± 5.4 weeks overall, significantly faster in early coverage group (18.4± 4.2 vs. 24.7± 5.8 weeks; $p<0.001$).

Table 2: Primary Outcomes by Gustilo Subclass and Coverage Timing

Outcome	III-A (n=42)	III-B (n=118)	III-C (n=27)	p-value
Deep infection rate, n (%)	2 (4.8)	19 (16.1)	6 (22.2)	0.012
Limb salvage rate, n (%)	42 (100)	108 (91.5)	25 (92.6)	0.183
Mean time to union (weeks)	16.2± 3.8	21.4± 5.1	24.8± 6.3	<0.001
Free flap utilization, n (%)	0 (0)	98 (83.1)	27 (100)	<0.001

Table 3: Multivariate Logistic Regression Analysis for Predictors of Deep Infection

Variable	Odds Ratio	95% CI	p-value
Coverage timing >7 days	3.82	1.45–10.07	0.007
Diabetes mellitus	2.94	1.18–7.32	0.021
Gustilo III-C injury	2.67	1.03–6.92	0.043
Wound contamination (farm/soil)	2.15	0.89–5.21	0.089
NPWT as bridge to closure	1.34	0.52–3.45	0.542
Age >50 years	1.28	0.49–3.35	0.618

Functional Outcomes and Secondary Endpoints

At 12-month follow-up, mean LEFS score was 62.4 ± 11.3 for lower limb injuries (n=148), significantly higher in early coverage group (68.7± 9.2 vs. 56.3± 12.1; p<0.001). Mean DASH score for upper limb injuries (n=39) was 28.6 ± 14.7, with early coverage associated with better function (22.4± 10.3 vs. 34.8± 16.9; p=0.008). Reoperation rate was 28.9% (54/187), primarily for hardware exchange (n=22), bone grafting (n=18), or wound revision (n=14). Mean hospital stay was 21.6± 14.3 days, significantly shorter with early coverage (16.8 ± 9.7 vs. 28.4 ± 17.2 days; p<0.001).

Table 4: Functional Outcomes at 12 Months Stratified by Coverage Timing

Outcome Measure	Early (<72h) n=69	Intermediate (72h–7d) n=78	Delayed (>7d) n=40	p-value
LEFS score (lower limb), mean± SD	68.7± 9.2	61.2± 10.8	56.3± 12.1	<0.001
DASH score (upper limb), mean± SD	22.4± 10.3	29.7± 13.6	34.8± 16.9	0.008
Return to work (% employed pre-injury)	84.3%	68.9%	52.1%	<0.001
Patient satisfaction (Likert 1–5), mean	4.2± 0.8	3.6± 1.1	3.1± 1.3	<0.001

Table 5: Complications Stratified by Flap Type (Free Flaps Only, n=128)

Complication	ALT Flap (n=54)	Latissimus Dorsi (n=24)	Rectus Abdominis (n=14)	Other Free Flaps (n=36)	p-value
Partial flap loss	2 (3.7)	1 (4.2)	1 (7.1)	2 (5.6)	0.892
Total flap loss	1 (1.9)	1 (4.2)	0 (0)	1 (2.8)	0.731
Donor site morbidity	3 (5.6)	4 (16.7)	2 (14.3)	3 (8.3)	0.043
Reoperation for flap	4 (7.4)	3 (12.5)	2 (14.3)	4 (11.1)	0.672
Deep infection	5 (9.3)	4 (16.7)	3 (21.4)	6 (16.7)	0.218

This Pakistani multicenter cohort shows that integrated orthoplastic care provides limb salvage in 93.6 percent of GG-III fractures with a high rate of deep infection of 14.4 per cent is significantly superior to historical controls in similar environments which reported an infection rate of 30-40 per cent. The most notable outcome is the vast influence of the time of coverage: patients with definitive soft tissue coverage that

happened in the first 72 hours had a rate of infections at 8.7% compared to 25.0% with delayed coverage (>7 days), which proves the importance of early reconstruction even in resource-restrained settings.

Multivariate analysis revealed three independent predictors of deep infection including delayed coverage (> 7days) and diabetes mellitus and Gustilo III-C. The results are in agreement with the international literature on the theme of race against time between bacterial growth and the coverage of soft tissues. Interestingly, the use of NPWT as a bridge to delayed coverage was found to be not associated with increased risks of infection at the expense of covering the flap immediately, which can be attributed to its possible use as a temporizing measure when the necessary operating room are logistically unavailable at a center of limited operating room.

Strong correlation was found between functional outcomes and coverage timing with early coverage patients having a significantly higher LEFS score and higher rates of return-to-work. This practical benefit is probably a lowered level of infection, decreased reoperation, and swifter rehabilitation that is important in the socioeconomic background of Pakistan in which timely disability would be disastrous to a family in terms of finances.

The 94.2% free flap survival rates match those of the international standards despite some of the limitations such as irregularity of the microscopes, limited access to postoperative monitoring and high ambient temperatures that can interfere with the flap perfusion. Such success highlights the fact that microsurgical reconstruction can be delivered in LMICs when done by committed teams that have formalized training tracks a trend that is becoming trendy in South Asia.

DISCUSSION

The current research paper shows that orthoplastic management is a relevant practice that could be successfully used to enhance the outcome of GG-III open fractures in the context of the resource-limited healthcare environment in Pakistan. A 93.6 percent limb salvage rate and 14.4 percent rate of deep infection is a significant improvement in comparison with the Pakistani data of 15-25 percent amputation rate of identical injuries in the past [23]. These findings support the idea that the orthoplastic paradigm viewed as possible in high-resource conditions only before can be effectively translated into LMICs by means of standardizing the protocols, training the teams, and allocating resources pragmatically.

We have found that the risk of deep infection is decreased by early soft tissue coverage (<72 hours) by 65% (OR 3.82) which supports seminal work by Godina and later meta-analyses [24]. This standard, however, is difficult to reach in Pakistan, with its own logistical issues, such as the lack of enough operating rooms at the time of the day (when elective cases are done), late arrival of the patients (because of transportation problems), and the shortage of microsurgical equipment at any moment. Our centers had to surmount these barriers in the following manners: (1) special slots of operations theaters occupied by orthoplastic surgical cases during evening / night shift; (2) preset microsurgical instrumentation in sterilization units; (3) cross-training of orthopedic residents in basic flap elevation to hasten their coverage when plastic surgeons were operating on concomitant cases. These proofs indicate that early coverage can be done without huge capital outlay that is critical in scaling coverage to the 200 plus district hospitals in Pakistan.

The rate of 14.4% infection is still too high compared with rates obtained at the European centers (5-10%), which reflects unavoidable limitations: poor access to culture-specific antibiotics because of cost barriers, increased growth of multidrug-resistant organisms in community-acquired trauma [26], and nutritional deficiencies that lead to poor wound healing among 24.6% of our patients. However, we have a 56% relative reduction to pre-protocol historical controls (32.6) at the same institutions [27], which demonstrates that systematic protocol implementation can produce significant changes even in the absence of optimal resources. It is noteworthy that diabetes became a predictor of independent infection (OR 2.94), which presupposes the necessity of aggressive perioperative glycemic control, as in Pakistan, 23.7% of adults have an undiagnosed diabetes level [28].

The 94.2% survival rate of 68.4% III-B/III-C injuries using free flap despite the concept of microsurgery as an impractical technique flouts the idea that microsurgery is impractical. Factors that succeeded were: (1) structured training of plastic surgeons on fellowship in microsurgery center of Aga Khan University involved use of loupe magnification (2.5x)

other than using operating microscope to see the location of perforators when microscope was not available; (2) perforator mapping by use of Doppler instead of using microscope to observe the location of perforators to reduce the time taken during an operation. Latissimus dorsi flaps recorded higher donor site morbidity than ALT flaps (16.7 vs. 5.6), which favors global trends according to which ALT flaps are the workhorse flaps [29]. Nevertheless, latissimus was still useful in the case of enormous defects (>200 cm2) or when the site of ALT donor is impaired by another injury a common condition in high-energy trauma.

External fixation, using Ilizarov was applied in 64.7% of cases, especially when there was loss of segments of bone or when the injuries were type III-C with need of vascular repair. Although the utilization of the circular frames requires technical skills and patient adherence, they presented some clear benefits in our environment, the possibility to adjust the alignment after the surgery and promoting wound care using frame windows [30]. Average of 20.3 weeks of union is an acceptable time in comparison to internal fixation series (18-22 weeks), which overrules the myth of fixation taking a long period of time to heal. Nevertheless, pin-site infections were noted among 38.2% of Ilizarov patients that were predominantly superficial and could be treated with topical antibiotics highlighting the importance of psychic pin care education. The results of functional outcome showed that there existed a sharp socio economic aspect as 52.1% of delayed-coverage patients went back to work when compared to 84.3% with early coverage. In informal economy where daily wages are the norm in Pakistan, every week of disability puts unimaginable financial burden in the hands of the informal sector [31]. This observation contends that early coverage does not just happen as a clinical need but it is an economic requirement that avoids poverty of households by hastening rehabilitation. It corresponded with functional outcome, and patient satisfaction scores presented higher levels of acceptance of reconstructed limbs in early coverage patients with residual deformity as a significant psychosocial outcome frequently ignored in technical outcome research.

Study weaknesses are that it is not randomized (although prospective enrollment reduced selection bias), and patients lost to follow-up (12.8%) were not included, and the authors were not able to control the variation in surgeon experience across centers. Also, cost-effort analysis was not done which is important in policy advocacy in resource-restricted environments. The research problems to be resolved by future studies are the following: comparison of orthoplastic and sequential care, formulation of Pakistan-specific MESS modifications with the introduction of socioeconomic variables, health economic studies in the form of disability-adjusted life years (DALYs) avoided by early coverage.

The National Trauma Registry initiative in Pakistan can be directly related to our findings. We suggest that it should be documented as mandatory (1) time to first debridement; (2) time to final soft tissue coverage; (3) flap type and survival; (4) deep infection at 6 weeks. This kind of data would be useful in quality benchmarking across centers as well as system-level obstacles to timely coverage. Moreover, the orthopedic and plastic surgery residency programs must be required by the Pakistan medical commission to include orthoplastic training modules with positive outcomes already seen at the Aga Khan University [32].

CONCLUSION

Integrated orthoplastic care does considerably enhance the limb salvage rates and lessen the deep infection in GG-III open fractures in the resource-limited healthcare system in Pakistan. Early soft tissue coverage in the first 72 hours is found to be the most important modifiable variable of risk of infection, time to union, functional recovery, and socioeconomic reintegration. The concept of free flap reconstruction can also be supported in the LMIC context and implemented successfully in the countries with the help of the specific training paths and realistic adjustments to the local limitations. Standardization of orthoplastic practices is a cost-efficient approach towards maximizing the outcomes of intricate trauma evidence in limbs that provides a model that can be duplicated in trauma services in South Asia and other resource-scarce areas.

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