Research Article

Impact of Early Soft Tissue Coverage on Outcomes of Complex Fractures: An Orthoplastic Perspective

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ABSTRACT

Objective: To determine the effects of definitive soft tissue coverage timing on clinical outcomes of patients undergoing an integrated orthoplastic management of Gustilo-Anderson Type IIIB/ IIIC open fractures.

MATERIALS and METHODS: It was a prospective cohort study, which recruited 186 patients with complex lower limb fractures that necessitated soft tissue repair. Patients were divided into two categories, depending on when they received definitive flap coverage Group A (early coverage ≤ 7 days, n=98) and Group B (delayed coverage >7 days, n=88). Deep infection rate, time to bony union, flap survival and limb salvage were the primary outcomes. The secondary outcomes were hospital length of stay, reoperation rate, and functional outcome measured using Lower Extremity Functional Scale (LEFS).

Results: At early stages, the rates of deep infection (12.2 vs. 34.1, p=0.001), flap survival (96.9 vs. 85.2, p=0.008), bony union (18.4+-4.2 vs. 24.7+-6.8 weeks, p=0.001), and length of stay (22.3+-7.1 vs. 31.8+-9.4 days, p=0.001) showed significant differences. The coverage timing (>7 days) was determined as an independent predictor of a deep infection by the multivariate logistic regression when adjusted by the severity of injuries, comorbidities and smoking status (OR 3.82, 95% CI 1.94-7.53, p<0.001).

Conclusion: Early definitive soft tissue coverage in the initial seven days of management makes a big contribution to clinical outcomes of complex open fractures using an orthoplastic model. Morbidity reduction can be optimized through socioeconomic challenges by implementing special orthoplastic teams in resource-constrained environments such as Pakistan.

Keywords: Orthoplastic Surgery, Soft Tissue Coverage, Open Fractures, Gustilo-Anderson Classification, Flap Reconstruction, Limb Salvage, Timing of Reconstruction.

INTRODUCTION

Complex fractures with a loss of soft tissues are one of the most problematic situations in the orthopedic trauma management, especially in low- and middle-income countries, where road traffic accidents are a major cause of traumatic injury [1]. The orthopedic trauma epidemiology in Pakistan is significantly high, with road traffic trauma taking up about 59 percent of the trauma presentations and orthopedic trauma making up 35 percent of all surgical trauma cases [2]. According to the National Health Survey of Pakistan, 49 per 1,000 children less than five years old experience non-fatal injuries, and

because of trauma-related orthopedic conditions, they cause a heavy socioeconomic burden on the families and healthcare services [3]. This has been worsened by the lack of access to specialized reconstructive services and the lack of tertiary centers that offer integrated orthoplastic services throughout the country [4].

The idea of orthoplastic surgery as the combined, concomitant treatment of multifaceted musculoskeletal trauma by orthopedic and plastic surgery groups has become the standard of high-energy trauma treatment with soft tissue injury [5]. In the past, the sequential protocol of initial

orthopedic stabilization and late plastic surgical referral usually led to long-term wound exposure, high incidence of infections and poor limb salvage results [6]. Paradigm shift to concurrent orthoplastic management has realized that bone will not heal in a condition of soft tissue loss; as such, skeletal stabilization and biological wound coverage should be done simultaneously rather than sequentially [7].

Open fractures, especially Type IIIB and IIIC Gustilo-Anderson injuries are unique with large losses of soft tissues, periosteal stripping, and contamination [8]. The Gustilo-Anderson classification system is the most common framework that is used in making management decisions despite the limitation in the inter-observer reliability that exists with Type III injuries [9]. Type IIIB fractures are characterized by a large amount of soft tissue loss accompanied by periosteal stripping and exposure of bone with a need to cover with flaps and Type IIIC fractures further include arterial injury that requires a vascular repair [10]. The infection rates of these injuries lie between 10-50 and amputation rates at 5-15, where the outcomes strongly depend on the nature and the timing of the soft tissue reconstruction in the initial study [11].

The key role of timing in soft tissue coverage is not a new finding, as the pioneering work of Godina in the 1980s had already proved the significant role that microsurgical free flap coverage in the first 72 hours of injury played in the rate of infection and enhancement of bony union [12]. Later developments have narrowed this definition pointing out that definite coverage in 7 days is a realistic limit of optimal results in resource-variable contexts [14]. Early coverage helps to avoid the desiccation of the exposed bone and tendons, bacteria colonization, minimization of complications because of edema, and the establishment of a vascularized space that supports fracture recovery [15]. In turn, later coverage (after 7-10 days) is associated with higher deep infection, nonunion, and hardware failure rates [16].

A conceptual ladder of re-construction through the simplest to most complex methods of covering wounds offers a systematic method of reconstruction in the soft tissue area [17]. But modern orthoplastic philosophy supports the principle of the reconstructive elevator that allows direct upward ascent to the most suitable reconstructive modality in accordance with

the features of defects instead of strictly moving through each step. In complex lower limb injuries, split-thickness skin grafts (superficial defects and intact periosteum) may be used, and the flaps may be local flaps (rotational, advancement, or perforator-based), or free tissue transfer (muscle, fasciocutaneous or osteocutaneous flaps) [18]. The strength of vascularity, pliability and ability to seal large defects are the benefits of free flaps which demand the skills of microsurgery and increase operative time [19]. Local flaps offer good coverage, single-stage procedures, but can have tissue availability and vascularity constraints in general locations of injury [20].

A number of factors in the Pakistani context have a dissimilar effect on the orthoplastic outcomes. Patients are sometimes presented long after injury because of socioeconomic barriers [21], often 24-72 hours after the injury because of transport constraints and financial restrictions. Other aspects of culture such as preference of traditional healers before hospital presentation only complicates timely intervention [22]. Availability of microsurgical instruments, specialized implants, and intensive care monitoring needed to conduct free flap monitoring all are affected by resource limitations [23]. Moreover, comorbidities like diabetes mellitus (having a comorbidity rate of 26% in adults in Pakistan) and tobacco use (smoking rate in males 19.6% in Pakistan) are factors that have detrimental effects on wound healing and flap survival [24]. Nevertheless, new developments in South Asian centers show that with the implementation of structured orthoplastic programs, it is possible to have results similar to the high-income nations given the available resources, when these programs are tailored to the country's available resources [12-13].

Negative pressure wound therapy (NPWT) has become a popular temporizing intervention in complex wounds, meta-analyses have indicated that it has low rates of infection compared to standard dressings [25]. But more recent high-quality evidence challenges its cost-effectiveness and indicates the possible risk of more risk of fracture related infection when it is administered as a protracted interim treatment before permanent coverage [10]. In resource-challenged areas such as Pakistan, NPWT can be a step towards ultimate reconstruction but

not to replace timely flap coverage where necessary [11].

These interdisciplinary challenges are met in the orthoplastic model by four main principles, which include: (1) active multidisciplinary assessment in the emergency department; (2) start with aggressive and serial debridement until viable tissue is obtained; (3) early skeletal fixation with external or internal fixation; and (4) final soft tissue coverage within 7 days as possible [26]. The combination of these methods is what maximizes the biological environment to heal as well as reducing the window of vulnerability to deep infection.

Even though the principles of orthoplastics gain popularity in the rest of the world, its application in Pakistan is still in pieces. The majority of trauma units are organized into sequential referral patterns instead of coordinated teams, which leads to essential delays in orthopedic stabilization followed by the consultation of plastic surgery. Microsurgery and complex reconstruction training programs are confined to only a few academic centers, and this results in geographic disparities in the availability of advanced reconstructive care. Moreover, the lack of standardized guidelines on the management of open fractures helps to create practice variability and limiting results.

This research fills an imperative evidence gap since it assesses the effect of the time of soft tissue cover on clinical outcomes in a Pakistani orthoplastic context. We assume that early unequivocal coverage (7 days) will considerably lessen deep infection rates, speed up bone consolidation, increase flap survival, and functional recovery in patients with Gustilo-Anderson Type IIIB/IIIC fractures. These relationships are crucial in creating context-specific protocols that would provide limb salvage as much as possible without going against resource limitations typical of Pakistani healthcare environment.

MATERIALS AND METHODS

This was a prospective cohort study that was based at multicentre teaching hospital across Pakistan. Informed consent was obtained by the use of written consent on all participants or their legal representatives. Selection of participants: Amongst consecutive adult patients (18 years) presenting with acute lower extremity (Gustilo-Anderson Type IIIB or IIIC) open fractures and who needed soft tissue reconstruction, were eligible during

January 1, 2024 to December 31, 2025. Inclusion criteria included: (1) age 18 years; (2) Gustilo-Anderson Type IIIB or IIIC fracture diagnosed by two senior orthopedic surgeons; (3) the need to cover the flaps (local or free) to be able to close the wound; (4) injury-to-hospital arrival time 72 hours; and (5) the ability to give informed consent or having a legal representative. Exclusion criteria were: (1) Gustilo Type I, II or IIIA fractures; (2) injured soft tissues and no fracture; (3) reported injury more than 72 hours after injury; (4) patient had previous peripheral vascular disease or neuropathy; (5) immunocompromised condition (HIV, chronic steroid use over 20 mg/day prednisone equivalent, chemotherapy by 3 months); (6) patient refusal of follow-up; (7) life-threatening polytrauma (Injury Severity Score The calculation of sample size was done using the G-power 3.1 software. A minimum of 86 patients per group was required based on a pilot study that showed a deep infection rate of 15 percent in young people who were covered early and 35 percent in young people who were covered late with alpha=0.05 with power=80. We expected the dropout rate to be 12% which is why we targeted 200 patients. Finally, 186 patients adhered to the protocol of the study. Emergency Department Phase (0-6 hours): Concomitant assessment by both orthopedic and plastic surgery teams. Primary survey in accordance with the guidelines of Advanced Trauma Life Support (ATLS). Photo of wound taken and gauged. Administration of tetanus prophylaxis. I.V. antibiotics commenced (cefazolin 2g + gentamicin 5mg/kg; penicillin 2g added to injuries in the farm). Fracture placed on splintage. Stereotyped covered wound with saline-moistened sterile gauze. Operating Room Phase 1 - First Debridement (within 12 hours): Radical surgical debridement under tourniquet control (lower extremity) jointly done by orthopedic and plastic surgeons. Vacuum-assisted closure (VAC) dressing with constant suction of 125 mmHg. Specimens to aerobic/anaerobic culture and sensitivity. The antibiotics administration after the debridement lasted 24 hours and were then reduced depending on the findings of the culture. Intermediate Phase (Days 1-5): Wound Inspection on a Daily basis. Repeat debridement done in case of nonviability of tissue (3 debridements limit). Viability of wound bed assessed and definitive reconstruction planned by Plastic

surgery team. Angiography that was used as a preoperative procedure before vascular repair in Type IIIC injuries. Nutritional optimization began (ral serum albumin goal of more than 3.5g/dL; oral supplementation or enteral nutrition as required). Glycemic control aimed (random blood glucose <180mg/dL in diabetics). Cessation counseling assistance is given. Definitive Reconstruction Phase: The time of Reconstruction is based on wound bed readiness (healthy granulation tissue, no necrotic tissue, negative wound edge cultures). Subjects who were stratified to two groups: Group A (Early Coverage): Definitive flap coverage 7 days after the injury. The choice of flaps was based on the principles of reconstruction: the local flaps include medial/lateral gastrocnemius, soleus, sural artery fasciocutaneous, propeller perforator flaps to use in the proximal/mid-tibial defects; free flaps include the anterior lateral thigh, latissimus dorsi, rectus abdominis, fibula osteocutaneous to use in the distal defects of the third part of the tibia or in case the local tissue is unavailable. Anastomoses with free flaps (made to recipient vessels outside of the zone of injury using an operating microscope (x2.5-4.0 magnification). Operative Flap perfusion confirmation by intraoperative Doppler.Orthopedic simultaneous did definitive internal fixation (intramedullary nailing or plate osteosynthesis) where these conditions of soft tissues allowed, and external fixation retained. Postoperative Phase: Flap (color, temperature, capillary refill, Doppler signal) monitoring every 48 hours during the first hour. NPWT stopped after 48 hours after flap. The duration of antibiotics was 72 hours after reconstruction. On postoperative day 2, physiotherapy commenced. Discharge criteria: afebrile 48 hours, can take oral fluids, flap viable, oral pain controlled, and outpatient follow-up is made. Data Collection: Demographic Data: age, gender, body mass index (BMI), socioeconomic status (modified version of the Kuppuswamy scale to Pakistan), education level, occupation, smoking status (current/ former/ never), comorbidities (diabetes, hypertension, peripheral vascular disease). Management variables: the interval between the injury and the first debridement, the number of debridement, the interval to the definitive coverage, the type of the flap (local or free), the type of fixation (external or internal), the use of NPWT time. Outcome measures: Primary: deep infection (purulent discharge with positive culture but needs to be debrided operatively), flap survival (loss >20 percent necrosis needs to be reoperatively debrided), time to bony union (radiographic bridging callus in 3 cortices), salvage of the limb (no amputation at end of follow-up), Secondary: length of stay in hospital, rate of reoperation (other than planned operations), time to full weight-bearing, score on LEFS at 6 months (0-80 points; higher=better functioning). Follow-up schedule: 2 weeks, 6 weeks, 3 months, 6 months, 12 months, postoperative. Radiographs at every visit till union has been proved. LEFS applied by blinded physiotherapist in 6 months. Statistical Analysis: Data was analysed using version 26.0 SPSS (IBM Corp., Armonk, NY). Continuous variables with the mean +- SD (standard deviation) or median (interquartile range) because of the normality (Shapiro-Wilk test). Nominal variables in form of percentages and frequencies. No differences of means were observed, thus the independent t-test (parametric) or Mann-Whitney U test (non-parametric) were used to compare the groups in case of continuous variables; the chi-square or Fisher exact test was used with categorical variables. Time-to-union Kaplan-Meier with log-rank test. Multivariate logistic regression to determine independent predictors of deep infection age, diabetes, smoking, Gustilo grade and time of coverage. Time-to-union Cox proportional hazards model. Statistical significance = p <0.05 (two-tailed).

RESULTS
Two hundred and forty-four patients were screened, 28 were excluded (12 came more than 72 hours after the injury, 8 had ISS>25, 5 immunocompromised, 3 refused to give consent). The last group of patients amounted to 186 patients: Group A (early coverage ≤ 7 days, n=98) and Group B (delayed coverage >7 days, n=88). The baseline demographics, injury characteristics, and comorbidities were similar in groups (all p.05) to compare them on equal terms (Table 1). The most common ones are road traffic accidents (82.3%), followed by the biggest subgroup of motorcyclists (46.8%). Gustilo IIIB fractures included 73.1 percent injuries; 26.9 percent IIIC vascular injuries.

Table 1: Baseline Characteristics of Study Cohort (N=186)

Variable	Group A (Early ≤7d) n=98	Group B (Delayed >7d) n=88	P-Value
Demographics			
Age (years), mean±SD	34.2±11.8	36.7±13.2	0.182
Male sex, n (%)	86 (87.8)	75 (85.2)	0.621
BMI (kg/m²), mean±SD	23.4±3.6	22.9±4.1	0.375
Smoker (current), n (%)	42 (42.9)	40 (45.5)	0.718
Diabetes mellitus, n (%)	18 (18.4)	19 (21.6)	0.583
Injury Characteristics			
Mechanism: RTA, n (%)	82 (83.7)	71 (80.7)	0.602
Gustilo IIIB, n (%)	73 (74.5)	63 (71.6)	0.664
Gustilo IIIC, n (%)	25 (25.5)	25 (28.4)	0.664
Tibial shaft fracture, n (%)	68 (69.4)	62 (70.5)	0.872
Associated vascular injury, n (%)	25 (25.5)	25 (28.4)	0.664
Compartment syndrome, n (%)	31 (31.6)	29 (33.0)	0.842
Management Variables			
Time to first debridement (hrs), mean±SD	8.3±3.1	9.1±4.2	0.147
Number of debridements, mean±SD	1.8±0.7	2.9±1.1	<0.001
NPWT duration (days), mean±SD	4.2±1.8	9.7±3.4	<0.001
Free flap utilization, n (%)	58 (59.2)	52 (59.1)	0.989

Statistically significant (p<0.05)

Early soft tissue coverage demonstrated significantly superior outcomes across all primary endpoints (Table 2). Deep infection occurred in 12 patients (12.2%) in Group A versus 30 patients (34.1%) in Group B (p<0.001). Flap survival was 96.9% (95/98) in Group A compared to 85.2% (75/88) in Group B (p=0.008), with complete flap loss necessitating reoperation in 3 patients (3.1%) versus 13 patients (14.8%), respectively. Time to radiographic bony union was significantly shorter in Group A (18.4±4.2 weeks) versus Group B (24.7±6.8 weeks) (p<0.001). Kaplan-Meier analysis confirmed accelerated union in the early coverage group (log-rank p<0.001) (Figure 1). Limb salvage was achieved in 95.9% (94/98) of Group A versus 84.1% (74/88) of Group B (p=0.012), with amputations performed for uncontrolled infection (n=6), flap failure with exposed hardware (n=3), and non-reconstructable vascular injury (n=1).

Table 2: Primary Clinical Outcomes by Coverage Timing

Outcome Measure	Group A (Early ≤7d) n=98	Group B (Delayed >7d) n=88	P-Value
Deep infection, n (%)	12 (12.2)	30 (34.1)	<0.001
Flap survival, n (%)	95 (96.9)	75 (85.2)	0.008
Complete flap loss, n (%)	3 (3.1)	13 (14.8)	0.006
Time to bony union (weeks), mean±SD	18.4±4.2	24.7±6.8	<0.001
Limb salvage, n (%)	94 (95.9)	74 (84.1)	0.012

Statistically significant (p<0.05)

Group A demonstrated significantly shorter hospital length of stay (22.3±7.1 vs. 31.8±9.4 days, p<0.001) and lower reoperation rates excluding planned procedures (15.3% vs. 38.6%, p<0.001) (Table 3). Time to full weight-bearing was achieved earlier in Group A (14.2±3.8 vs.

19.6±5.7 weeks, p<0.001). Functional outcomes at 6 months measured by LEFS favored early coverage (62.3±11.4 vs. 51.8±14.2 points, p<0.001), with 78.6% of Group An achieving good/excellent function (LEFS >60) versus 52.3% in Group B (p<0.001).

Table 3: Secondary Outcomes and Functional Results

Outcome Measure	Group A (Early ≤7d) n=98	Group B (Delayed >7d) n=88	P-Value
Hospital LOS (days), mean±SD	22.3±7.1	31.8±9.4	<0.001
Reoperation rate, n (%)	15 (15.3)	34 (38.6)	<0.001
Time to full weight-bearing (weeks), mean±SD	14.2±3.8	19.6±5.7	<0.001
LEFS score at 6 months, mean±SD	62.3±11.4	51.8±14.2	<0.001
Good/excellent function (LEFS>60), n (%)	77 (78.6)	46 (52.3)	<0.001

Excluding planned secondary procedures (hardware removal, flap debulking) Statistically Significant (p<0.05)

Multivariate logistic regression identified coverage timing >7 days as an independent predictor of deep infection after adjusting for age, diabetes, smoking, Gustilo grade, and number of debridements (adjusted OR 3.82, 95% CI 1.94–7.53, p<0.001) (Table 4). Diabetes mellitus also emerged as an independent risk factor (adjusted OR 2.41, 95% CI 1.12–5.19, p=0.024). Cox proportional hazards analysis for time to union demonstrated that early coverage was associated with 2.3-fold faster union (HR 2.31, 95% CI 1.74–3.07, p<0.001) after adjusting for fracture pattern and fixation method (Table 5).

Table 4: Multivariate Logistic Regression for Deep Infection (N=186)

Variable	Adjusted Odds Ratio	95% CI	P-Value
Coverage timing >7 days	3.82	1.94–7.53	<0.001
Diabetes mellitus	2.41	1.12–5.19	0.024
Gustilo IIIC (vs. IIIB)	1.87	0.89–3.92	0.098
Current smoking	1.54	0.76–3.12	0.231
Age (per 10-year increase)	1.12	0.94–1.34	0.207

Statistically significant (p<0.05)

Table 5: Cox Proportional Hazards Analysis for Time to Bony Union

Variable	Hazard Ratio	95% CI	P-Value
Early coverage (≤7 days)	2.31	1.74–3.07	<0.001
Intramedullary nailing (vs. plating)	1.42	1.08–1.87	0.013
Non-diabetic status	1.68	1.21–2.34	0.002
Absence of deep infection	2.05	1.53–2.75	<0.001
Gustilo IIIC (vs. IIIB)	0.71	0.53–0.95	0.021

Statistically significant (p<0.05)

Stratification according to the flap type showed that advantageous benefits of the initial coverage remained in the local and free flaps. With free flaps (n=110), it was found that the rates of early coverage were lower (13.8 vs. 36.5, p=0.009) and the flaps survival higher (98.3 vs. 86.5, p=0.032). Equally, in local flap recipients (n=76), early coverage decreased infection (10.0% vs. 30.8, p=0.041) but flap survival did not differ significantly (95.0% vs. 80.8, p=0.102) presumably because the sub-group size was smaller.

DISCUSSION
This is a prospective cohort study by a Pakistani tertiary care that showed that

early definitive soft tissue cover within 7 days is significant in enhancing clinical outcomes of complex open fractures treated in an integrated orthoplastic approach. We are able to support the principle, which was expressed by Godina thirty years ago: the sooner it is covered, the better it works [25]. The 12.2% deep infection rate in our early coverage group is similar to the present series in high-income countries with 10-20% with timely reconstruction reporting 12.2% infection rates in their orthopedic protocols [26], which is encouraging to claim that resource-adequate orthopedic protocols will yield similar results, even with the limitations of socioeconomic status.

The most clinically important result of our study is the 21.9% absolute decrease in deep infection with an early cover (12.2% vs. 34.1% p of <0.001). This size of effect is similar to systematic reviews showing about a 50% decrease in infection risk in coverage during 72 hours, versus delayed reconstruction [20]. Biological reasons are multifactorial: early coverage deters colonization of the exposed bone and hardware with bacteria, keeps the tissue hydrated, local vascularity intact before fibrosis ensues and forms a vascularized barrier to ascending infection [27]. Using multivariate analysis, in our group, coverage timing >7 days showed to be the strongest independent predictor of deep infection (adjusted OR 3.82), and it was higher than conventional risk factors such as diabetes and smoking. This highlights that timing is one of the factors that can be altered by clinicians but not the patient comorbidity.

Our flap survival rate in those cases was higher than that of other donors because of early coverage (96.9 vs. 85.2, p=0.008) with past studies nonetheless worrying that the early reconstruction would weaken the viability of the flap because of residual inflammation or undiagnosed nonviability tissue [28]. The current knowledge states that adequate initial debridement and not delayed coverage are the decisive factors of flap success [29]. Our policy required radical debridement till punctuate bleeding was shown, proceed with repeat procedures when necessary to have a viable wound bed before coverage, even in the face of time. This strategy can be used to understand why early coverage did not lead to more flap loss even though there were theoretical reasons of operating in an inflammatory zone. The 11.7% absolute increase in flap survival is directly proportional to the increase in limb salvage since our 11.8% experience of higher salvage rate in Group A.

The symbiotic relationship between the soft tissue envelope and the fracture healing is manifested by accelerated bony union of the early coverage group (18.4 vs. 24.7 weeks, p<0.001). The use of vascularized flaps supplies oxygen, nutrients, and progenitor cells to the fracture bed and eliminates metabolic wastes [30]. Early coverage also allows earlier passage to definitive internal fixation in most instances good of mechanical stability favouring union [31]. In our Cox regression analysis, early coverage was the best predictor of union velocity (HR 2.31), which was independent of fixation method. Such a discovery has far reaching socioeconomic consequences in Pakistan whereby sustained disability directly affects the household income and disastrous health spending [32].

The difference of the functional outcome (LEFS 62.3 vs. 51.8, p<0.001) illustrates that the benefits of early coverage go beyond the biological outcomes to patient-centered outcomes. Previous weight-bearing, less pain during chronic wounds, and reduced reoperations are all indicators of better functional recovery. It is worth noting that 78.6 of early coverage patients had good/excellent functioning compared with only 52.3 of delayed group a 26.3% absolute difference with a significant quality-of-life implication. Even small functional gains in a society where manual work is the main feature could spell the difference between economic prosperity of injured patients and their families [33].

By applying our findings to the context of the healthcare situation in Pakistan, we can see both the challenges and opportunities. The dominance of RTAs (82.3%) is similar to the national epidemiology where poor road infrastructure, laxity in enforcing traffic laws, and poor access to pre-hospital care are some of the factors that increase high-energy trauma burden [28]. The overall amputation rate (15.1 per cent) is higher than in the Western series (5-10 per cent), with better results in early coverage, due to late presentation, inaccessibility of microsurgical skill other than in major cities and affordability of long-term rehabilitation expenses [34]. However our results show that this gap can be reduced using systematic orthoplastic regimens.

The scarcity of resources forced practical modifications of the western orthoplastic models. NPWT was an appropriate temporizing intervention; however was restricted to less than 7 days to avoid delay on definitive coverage a balance which was reinforced by emerging evidence questioning the use of NPWT over time [35]. The use of free flaps (59.2) was also less than the high-income centers (>80) because of the lack of microscopes and the absence of microsurgical training equipment. Nevertheless, the applicability of the strategic application of trusted local flaps (gastrocnemius, sural fasciocutaneous) brought similar results to the rightly chosen defects, confirming the reconstructive elevator concept [32]. The use of cost factors affected the choice of antibiotics (cefazolin/gentamicin instead of more broad-spectrum agents) and the choice of implants, although the rates of infections were not too high in the case of protocol compliance.

We have single-center study limitations because of resource-constrained study designs. There is a risk of selection bias even with consecutive enrollment because patients who came more than 72 hours after injuries were not included, which is a large percentage of real life Pakistani trauma. The 7 days timing window, though pragmatic, may not be the best biological window, subgroup analysis showed that benefits were also in the early group in terms of coverage [?]3 days versus 4-7 days, but the subgroup analysis lacked the power to draw conclusions. The case of the intervention did not allow blinding. They did not capture more than 12 months since long term outcomes were not included to capture late complications such as nonunion or hardware failure. However, our follow-up rate of 12 months is 89.2-percent, which is higher than most of the trauma studies in our setting [36]. Most importantly, governmental intervention measures, which decreased the occurrence of RTA, improved the road engineering design, helmet/seatbelt laws, and graduated driver licensing would decrease the burden at its inception [37].

To sum up, the current research yields Level II evidence that timely soft tissue cover in the 7-day range is highly effective in reducing the number of infections, flap survival, bony fusion, and functional results with complex fractures treated using an orthoplastic approach in Pakistan. Although resource scarcity demands the need to make pragmatic decisions in adaptation, the essence of timely biological coverage cuts across economic boundaries. Even in resource-limited settings, limb salvage can be maximized by implementation of specific orthoplastic teams, standard protocols, and specific training, and turned devastating injuries into salvageable limbs that provide meaningful function.

CONCLUSION
Early conclusive soft tissue cover in a period of 7 days, has a great influence on clinical outcomes in complex open fractures treated by an integrated orthoplastic approach in a Pakistani setting. This prospective cohort study proves timely reconstruction to reduce deep infection rate by 21.9 percent and improve flap survival by 11.7 per cent, speedy bony union by 6.3 weeks and increase functional recovery over delaying coverage more than 7 days. Time to coverage was found to be the

most effective independent predictor of deep infection when compared to comorbidity and injury severity. Application of special orthoplastic units that have uniform timing indices should be of priority in Pakistan trauma centers to maximize the outcome and save socioeconomic impact of complicated orthopedic trauma.

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