OPTIMIZATION OF THE TIMING AND METHODS OF SOFT-TISSUE DEFECT CLOSURE IN OPEN TIBIAL FRACTURES AT HIGH RISK OF INFECTION

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Relevance. Open tibial fractures with soft-tissue loss have a high risk of contamination, devascularization, deep infection, osteomyelitis, and nonunion. Successful reconstruction requires fracture stabilization and rapid restoration of a durable, vascularized soft-tissue envelope. Delayed coverage leaves bone, tendons, vessels, and implants exposed, increases wound manipulation, and may prolong inflammation and hospital treatment. However, closure performed before adequate debridement can retain necrotic tissue and microorganisms, producing early failure. The optimal strategy therefore requires coordinated assessment of defect size, level, vascular status, contamination, fracture stability, and donor-site availability. Available options include tension-free primary closure, local rotational or perforator flaps, muscle flaps, fasciocutaneous free flaps, and temporary dressings before definitive reconstruction. Current standards favor combined orthoplastic planning and early definitive coverage, yet delays remain common because of patient instability, transfer, operating capacity, or specialist availability. Determining appropriate timing and selecting the least morbid reliable method are essential for reducing infection and preserving limb function.

Research objective. The study aimed to optimize the timing and selection of soft-tissue defect closure in open tibial fractures at high infectious risk by comparing primary closure, local flaps, and free-tissue transfer, while evaluating deep infection, flap failure, osteomyelitis, fracture union, reoperations, hospitalization, and functional recovery, and developing an orthoplastic algorithm based on defect characteristics, vascular status, contamination, fixation, and patient condition.

Materials and Methods. The analysis included guidelines, cohort studies, and prospective investigations involving high-energy open tibial fractures requiring soft-tissue reconstruction. Stratification considered Gustilo-Anderson grade, defect size, location, vascular injury, contamination, comorbidity, and fracture pattern. Reconstructive approaches comprised tension-free primary closure, local rotational or perforator flaps, muscle flaps, fasciocutaneous free flaps, and temporary negative-pressure dressings before definitive coverage. Timing was assessed from injury, initial debridement, and definitive fixation to

wound closure. Primary outcomes were deep surgical-site infection, fracture-related infection, and flap failure. Secondary outcomes included osteomyelitis, unplanned debridement, nonunion, amputation, length of stay, donor-site morbidity, and functional recovery. Treatment quality was evaluated according to adequacy of debridement, fixation stability, vascularized coverage of exposed structures, and orthoplastic coordination. Comparative effects were summarized with risk ratios, adjusted associations, confidence intervals, and qualitative synthesis. Potential confounding from injury severity, transfer delay, physiological instability, and institutional resources was considered when interpreting relationships between coverage timing and clinical outcomes.

Results. lower infection, osteomyelitis, and reoperation rates than prolonged open-wound management. Standards recommend fixation and definitive soft-tissue coverage within seventy-two hours when immediate reconstruction is not feasible. Multicenter data showed delays beyond seven days were associated with higher complication rates, although injury severity and transfer factors influenced this relationship. Tension-free primary closure was appropriate only when devitalized tissue had been removed and wound edges remained viable without compromising perfusion. Local rotational, perforator, or muscle flaps were useful for proximal and middle-third defects with reliable adjacent tissue and vascular supply. Free-tissue transfer provided coverage for large, distal, circumferential defects exposing bone, tendon, vessels, or implants. Flap selection depended on defect geometry, vessels, donor-site morbidity, rehabilitation, and the need to obliterate dead space. Temporary negative-pressure dressings protected the wound between procedures but did not justify delaying definitive reconstruction. Internal fixation was safest when followed by vascularized coverage. The optimal model was a coordinated orthoplastic pathway linking early debridement, fixation planning, vascular assessment, flap selection, and scheduled coverage. These findings support risk-adapted reconstruction rather than a uniform technique for all injuries. Prospective studies should standardize infection definitions, functional measures, and long-term follow-up.

Conclusion. Early soft-tissue reconstruction is a component of infection prevention in high-risk open tibial fractures. Definitive coverage should follow complete debridement and stable fixation without avoidable delay, preferably within orthoplastic time targets. Primary closure is suitable only for tension-free wounds, whereas local or free flaps should be selected according to defect location, size, vascularity, and exposed structures. Temporary dressings remain bridging measures. A differentiated algorithm can reduce treatment variability, improve reconstructive reliability, and support better infection, union, limb-salvage, and functional outcomes.