EFFECTIVENESS OF LOCAL ANTIBACTERIAL CARRIERS IN PREVENTING INFECTIOUS COMPLICATIONS OF OPEN TIBIAL FRACTURES

Khojiev Shokhabbos Abdurakhmonovich
Department of Traumatology and Orthopedics
Andijan State Medical Institute

Relevance Severe open tibial fractures combine soft-tissue injury, contamination, impaired perfusion, and unstable bone fragments, creating conditions for biofilm formation and fracture-related infection. However, antibiotic delivery to devascularized tissues may be limited. Local antibacterial carriers, including powders, polymethylmethacrylate beads, calcium sulfate composites, and matrices, can produce high antimicrobial concentrations within the wound while reducing systemic exposure. They may also fill dead space after debridement and provide sustained drug release. Nevertheless, carrier behavior varies by material, antibiotic, bacterial susceptibility, drainage, and tissue condition. Excessive concentrations may impair cellular viability, nonabsorbable material may require removal, and uncontrolled use may promote resistance or wound leakage. Current trials support selected applications, but not routine use of every carrier or multidrug combination. Therefore, evaluation is needed to determine indications, safety, antibiotic loading, release characteristics, and effectiveness in tibial fractures. Such evidence could improve prevention without replacing systemic antibiotics, meticulous debridement, stable fixation, and timely soft-tissue coverage.

Research objective. The study aimed to evaluate the effectiveness and safety of local antibacterial carriers for preventing purulent-inflammatory complications after open tibial fractures by analyzing their influence on deep surgical-site infection, fracture-related infection, osteomyelitis, wound healing, repeated debridement, fracture union, adverse reactions, and antimicrobial resistance, while determining indications, carrier types, antibiotic selection, timing, and integration with systemic prophylaxis and surgery in patients.

Materials and Methods. The analysis included randomized trials, prospective and observational studies evaluating local antibiotic delivery in high-risk or open tibial fractures. Interventions included vancomycin or aminoglycoside powder, antibiotic-loaded polymethylmethacrylate beads, absorbable calcium sulfate carriers, hydrogels, and biodegradable matrices. Control groups received systemic prophylaxis and surgical management without a local carrier or with an alternative local formulation. Extracted variables included fracture pattern, Gustilo-Anderson grade, contamination,

soft-tissue damage, debridement quality, fixation method, carrier composition, antibiotic dose, elution profile, and timing of wound coverage. Primary outcomes were deep surgical-site infection and fracture-related infection requiring surgery. Secondary outcomes included gram-positive and gram-negative infection, osteomyelitis, repeat debridement, nonunion, wound leakage, renal toxicity, resistance, and reoperation for carrier removal. Risk of bias was assessed according to study design, outcome adjudication, follow-up completeness, and confounding control. Comparative effects were summarized using risk differences, relative risks, confidence intervals, and qualitative synthesis when statistical pooling was inappropriate because of clinical heterogeneity.

Results. Evidence synthesis indicated that local antibiotic delivery can achieve high antimicrobial exposure and may reduce selected infection outcomes when combined with systemic prophylaxis and surgical care. In a randomized trial of high-risk tibial plateau and pilon fractures, intrawound vancomycin powder produced a 3.4-percentage-point reduction in the probability of deep infection, although the primary comparison narrowly missed statistical significance. The benefit was concentrated in gram-positive infections, consistent with vancomycin activity, while gram-negative infection was unchanged. Recent randomized evidence showed that adding tobramycin powder to vancomycin did not reduce deep surgical-site infection compared with vancomycin alone, demonstrating that broader local coverage does not automatically improve prevention. Antibiotic-loaded beads and biodegradable carriers offered dead-space management and sustained release, but supporting studies were heterogeneous and often observational. Nonabsorbable carriers could require later removal, whereas absorbable calcium-based materials were associated with prolonged wound drainage. Effectiveness depended on radical debridement, carrier placement, perfusion, fixation stability, timely wound closure, and microbiological risk. Local carriers did not replace intravenous prophylaxis or definitive soft-tissue reconstruction. Overall, evidence supported selective, pathogen-directed or risk-adapted use rather than universal application. Further controlled trials should compare carrier materials, release kinetics, toxicity, resistance, fracture healing, and long-term functional outcomes specifically in open tibial fractures.

Conclusion. Local antibacterial carriers are promising adjuncts for preventing infectious complications after open tibial fractures, particularly when high local concentrations are required. Evidence supports intrawound vancomycin against gram-positive infection in high-risk tibial fractures, but adding additional antibiotics does not necessarily improve outcomes. Carrier selection must consider biodegradability, elution, tissue compatibility, drainage,

resistance, and removal requirements. These systems cannot substitute for systemic prophylaxis, radical debridement, stable fixation, and timely coverage. Standardized trials in open fractures remain necessary before universal protocols are recommended.