Articular Fragment Restoration Is Critical to Mitigate Post-traumatic Osteoarthritis in a Porcine Pilon Fracture Model

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Purpose: During articular fracture reconstruction, orthopaedic surgeons are frequently faced with the dilemma of retaining small articular fragments versus discarding these fragments. The purpose of this study was to compare posttraumatic osteoarthritis (PTOA) development between pilon fractures and pilon fractures with missing articular fragment (MF) in a live porcine model.

Methods: High-energy tibial plafond fractures were created in skeletally mature Yucatan mini-pigs using a validated, custom apparatus to deliver a linear impaction force. The anterior tibia cortex was cut with a saw in order to create a reproducible, partial articular fracture. The fractures were anatomically reconstructed with 3.5-mm plates. During surgery, a 2 × 2-mm section of plafond articular surface along the fracture was removed in 6 animals (MF group). Contralateral ankle joints served as controls. Animals were casted for 2 weeks and permitted to be full weight-bearing. Ankle joint synovial fluid was obtained at initial surgery and at 12-week necropsy. Synovial fluid was analyzed for inflammatory cytokine concentrations including interleukin (IL)-1b, IL-1Ra, IL-6, IL-8, and IL-10. The tibial samples were explanted, fixed in 10% neutral buffered formalin (NBF), and processed for histological analyses. Scanning electron microscopy was performed to evaluate subchondral bone porosity. Histologic sections were stained with Sanderson's rapid bone stain, Toluidine blue, or Safranin O and evaluated for vascular invasion (VI) and osteoarthritis score (Osteoarthritis Research Society International [OARSI] system) by a blinded bone pathology technician. Paired and unpaired two-tailed Student t tests were performed after confirming data normality using the Wilk Shapiro test. A P value <0.05 was considered significant.

Results: 11 of the 12 animals made it to the 3-month end point. One animal developed a postoperative infection and underwent early euthanasia. Fractured ankles had significantly greater concentrations of IL-1b, IL-1Ra, IL-6, IL-8, and IL-10 as compared to control ankles at T0 ($P<0.05$). There was no difference in cytokine concentrations between fractured and fractured + MF ankles at either T0 or T12weeks. Fractured ankles had significantly greater bone porosity, VI, and OARSI grade as compared to the control group, all consistent with greater development of PTOA. In comparing the fracture group with the MF group, the MF group had significantly more bone porosity (35% vs 19%, $P = 0.001$), more VI (1.15 vs 0.5, $P = 0.013$), and higher average OARSI grade (3.8 vs 2.3, $P = 0.011$) than the fracture group.

Conclusion: Articular fractures with a missing fragment had significantly worse PTOA development as measured by bone porosity, VI, and cartilage histologic grade than anatomically reconstructed articular fractures. Clinically, orthopaedic surgeons should make every effort to retain and reconstruct articular fragments in order to mitigate PTOA development.