Three-dimensional reconstruction of fracture callus morphogenesis

Rat and mouse femur and tibia fracture calluses were collected over various time increments of healing. Serial sections were produced at spatial segments across the fracture callus. Standard histological methods and in situ hybridization to col1a1 and col2a1 mRNAs were used to define areas of cartilage and bone formation as well as tissue areas undergoing remodeling. Computer-assisted reconstructions of histological sections were used to generate three-dimensional images of the spatial morphogenesis of the fracture calluses. Endochondral bone formation occurred in an asymmetrical manner in both the femur and tibia, with cartilage tissues seen primarily proximal or distal to the fractures in the respective calluses of these bones. Remodeling of the calcified cartilage proceeded from the edges of the callus inward toward the fracture producing an inner-supporting trabecular structure over which a thin outer cortical shell forms. These data suggest that the specific developmental mechanisms that control the asymmetrical pattern of endochondral bone formation in fracture healing recapitulated the original asymmetry of development of a given bone because femur and tibia grow predominantly from their respective distal and proximal physis. These data further show that remodeling of the calcified cartilage produces a trabecular bone structure unique to fracture healing that provides the rapid regain in weight-bearing capacity to the injured bone.