Optimization of Autogenous Bone Grafting in the Induced Membrane Technique in a Small Animal Segmental Bone Defect Model

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Purpose: The induced membrane technique (IMT), also known as the Masquelet technique, is a 2-stage surgical approach used to manage nonunions and segmental bone defects. Since its inception, multiple variations of this technique have been described in clinical research but the optimal approach has not yet been determined. While several animal models have been developed to study this technique, bone grafting protocols and bone healing have rarely been reported and are highly variable. This study was aimed at optimizing bone grafting in a rat model of the IMT in order to achieve consistent healing outcomes.

Methods: A model of the IMT in Fischer 344 rats was established by creating a 5-mm defect in the femur. The defect was then filled with a polymethylmethacrylate spacer and stabilized with a plate and screws. Four weeks later, the spacer was removed with preservation of the membrane. Bone grafting was harvested from an isogenic donor rat and placed into the defect, followed by closure of the membrane and incision site. Experiments were conducted in 2 separate groups. In group 1, bone graft was harvested from the proximal femur, distal femur, proximal tibia, and pelvis, resulting in a variable amount of cortical and cancellous bone. The time from donor sacrifice to grafting was up to 240 minutes. One donor Fischer 344 rat provided bone graft for 5-6 isogenic graft recipients. In group 2, bone graft was harvested from vertebral bodies instead of the pelvis (in addition to the femur and tibia) and a high-speed burr was used to reduce the contribution of cortical bone to the graft. In addition, the time from donor sacrifice to grafting was strictly limited to under 120 minutes in all animals. To achieve this, 1 donor rat was used for 3-4 isogenic graft recipients. The volume of graft used and all other aspects of the intervention were standardized in both groups. Healing rates between groups were compared on the basis of serial radiographs.

Results: There were 17 animals in group 1, and 16 animals in group 2. In all animals, removal of the cement spacer was feasible at 4 weeks, fixation remained stable, and there was an identifiable membrane that could be used to contain the graft. Radiographic assessment at 8 weeks post bone grafting demonstrated a union rate of 23% in group 1 versus 87% in group 2.

Conclusion: We were able to develop a consistent and effective model of the IMT in Fischer 344 rats. We found several key steps to optimize the bone grafting technique in our model including: the use of vertebral bodies and cancellous portions of the femur and tibia, use of a high-speed burr to minimize the contribution of cortical bone to the graft, and limiting donor sacrifice to grafting time below 120 minutes. These modifications resulted in a significant increase in the healing rates in our model. This optimized model may serve as a guide for further preclinical investigation of the IMT.