3D-Printed Titanium Cages Combined with Masquelet Technique for Reconstruction of Bone Defects

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Purpose: The purpose of this study was to use custom 3-dimensional (3D) printed titanium cages as a novel treatment strategy to manage post-traumatic segmental bone loss. The cages act as a framework for bone graft, and were used here in combination with the Masquelet induced membrane technique.

Methods: Data were collected prospectively for 8 consecutive cases. The PMMA spacer remained in place for 10-12 weeks, following the Masquelet technique. 3D-printed titanium truss cages were implanted into the defect within the Masquelet membrane, and filled with autograft/allograft prior to implantation. The length and volume of the defect, length of surgery, incidence of infection, complications, need for blood transfusion, time to weight bearing, range of knee motion, rate of union, and rate of readmission were recorded. Samples from the induced membrane and control samples from normal local fascia were harvested to investigate biological activity using RNA-Seq gene analysis. Additional samples were collected for histologic evaluation.

Results: Custom 3D-printed titanium truss cages were used in 8 patients (6 male and 2 female; mean age, 53.1 years [range, 26-73]), to reconstruct 5 femurs, 1 tibia, 1 proximal humerus, and 1 midfoot. There was a mean interval between stages of 12.7 weeks (range, 11-15). The mean segmental defect measured 9.7 cm (range, 2.2-18.4). The mean bone defect volume measured 108 cc (range, 8-239). The mean length of follow-up was 8 months (6-28 months). There were no infections and no nonunions identified. Induced membrane analysis revealed up-regulation of genes associated with initiation of fracture healing. For example, vascular endothelial growth factor (VEGF), an essential gene mediating the process of angiogenesis, was highly up-regulated relative to the control specimens. Likewise, genes responsible in osteogenesis (transforming growth factor beta [TGFβ], bone morphogenetic protein [BMP]-2, receptor activator of nuclear factor kappa-B ligand [Rankl], Osterix, interleukin [IL]-6, IL-17) were up-regulated relative to the control specimens.

Conclusion: The use of patient-specific 3D-printed titanium cages, together with the Masquelet technique, is a promising new treatment option for managing complex segmental bone loss. Placing a patient-specific custom titanium implant into the highly favorable microenvironment created by the induced membrane consistently resulted in complete osseous integration of the truss implants. This was clearly demonstrated by up-regulation of the genes involved in the inflammatory, angiogenic, and osteogenic pathways.