Does Hyperbaric Oxygen Therapy Improve Bone Regeneration With Mesenchymal Stem Cells

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Disclosures:

Introduction: The treatment of severe long bone defects continues to pose a considerable challenge to orthopedic surgeons. Autologous mesenchymal stem cells concentrates in combination with bone substitute materials have been shown to support bone regeneration [1]. However, compromised vascularization and decreased oxygen supply may hinder effective osteogenesis. A way to improve oxygen supply and angiogenesis in healing tissues is hyperbaric oxygen therapy (HBOT) [2, 3]. This study aims to evaluate the effects of HBOT on regeneration of critical sized bone defects in weight-bearing diaphysal bones treated with porous calcium granules (CPG) in combination with bone marrow aspiration concentrate (BMC) in a rabbit model.

Methods: In 24 New-Zealand white rabbits a critical-sized bone defect was created in the radius diaphysis. All defects were filled with a composite of CPG and autologous BMC obtained by gradient centrifugation of bone marrow aspirate from the iliac crest. Animals were allocated to 2 treatment groups consisting of 12 animals each: The Non-HBOT group did not receive additional HBOT treatment and in the HBOT group oxygen was administered in an HBO chamber at pressures of 2.4 atm for 90 minutes per day on 5 days per week for the duration of the study [4]. Six animals of each group were sacrificed after 3 and 6 weeks postsurgery.

BMC was analyzed by cell counting, colony-forming-units (CFU), FACS analysis of surface markers, and cell characteristics. At the end points bone regeneration was evaluated using cone-beam computed tomography (CBCT) and histomorphometry [5]. The resorption of CPG was evaluated and angiogenesis in the defect area was evaluated by immunohistochemistry.

Results: Radiologic and histomorphometric results after 3 and 6 weeks showed signs of bone regeneration in all groups. Bone formation was significantly improved after 6 weeks compared to 3 weeks. Groups treated with additional HBOT showed significantly more bone formation compared to Non-HBOT groups. Immunohistochemistry displayed a significant increase in angiogenesis in HBOT groups compared to Non-HBOT groups. Cell counting displayed a significant increased concentration of mononuclear cells in BMC compared to bone marrow aspirate. By analysis of CFU and surface markers the stem cell characteristics were displayed.

Discussion: This study shows a significant increase in bone formation in critical-sized diaphyseal defects of weight-bearing long bones treated with CPG and BMC with additional HBOT in a rabbit model. Furthermore angiogenesis was significantly increased with HBOT. The increase in perfusion as a result of increased angiogenesis may play a key role in the effects of HBOT observed in this study.

Significance: Due to the positive effects of HBOT on regeneration of bone defects treated with bone substitute materials and autologous stem cells HBO could improve the treatment of patients with bone defects.

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References: