• EFFECT OF OSTEOGENIC PROTEIN-1 ON EXTRACORTICAL BONE AND INGROWTH OVER POROUS-COATED SEGMENTAL REPLACEMENT PROSTHESIS USING ALLOGENIC CORTICAL BONE ONLAY GRAFTING

*Fukuroku, J; *Inoue, N; *Raflee, B; *Matsuura, M; *Tan, X; *Frassica, F; +*Chao, E (A-Stryker-Howmedica-Osteonics) +*Orthopaedic Biomechanics Laboratory, Johns Hopkins University, Baltimore, Maryland. 410-502-6416, Fax: 410-502-6414, eyschao@yahoo.com

INTRODUCTION: Prosthetic reconstruction with extracortical bone bridging and ingrowth (EBBI) is an effective method of limb salvage after resection of malignant and aggressive benign tumors [1]. The effectiveness of autogenous onlay cortical bone and cancellous bone grafting using an innovative technique for EBBI formation in prosthetic reconstruction has been shown in previous studies [2]. However, autogenous graft is not always available and often limited in size and amount, an alternative biomaterial with osteogenic enhancement would be necessary to achieve the same goal. We evaluated the effect of osteogenic protein-1 (OP-1) for EBBI formation when allogenic cortical bone strips are used for the onlay grafting technique on porous-coated segmental prostheses in the mid-diaphyseal region of canine femora.

METHODS: Eight adult canines were used. Previously harvested canine mid-femoral and tibial diaphysis stored at –80 °C were used as allograft sources. These bones were cut into bone strips (30 x 2 x 2 mm). After defatting, these bones were stored at –80 °C for 3 days. Sixteen bone strips were tied down using non-absorbable sutures with a 1-2 mm gap. At 2 weeks before surgery, the bone strips were sterilized with ethylene oxide. A 6 cm segment of mid-femur was resected bilaterally and reconstructed with a bi-stemmed porous-coated segmental prosthesis. The stems were fixed with bone cement. Cortical bone allograft strips were placed at the junction between the femur and the prosthetic surface. On the experimental side, OP-1 (2.5 mg) mixed with collagen type I putty was applied under and between the cortical bone strips (Fig. 1). On the control side, autogenous cancellous bone particles (13 ml) were applied under and between the cortical bone strips. Before surgery and 4, 7, 10, and 12 weeks after surgery, dynamic weight bearing was determined. AP and ML radiographs were made preoperatively and 1, 2, 4, 6, 9, and 12 weeks following surgery. The area of bone bridging over the prosthetic surface was measured. The animals were sacrificed 12 weeks after surgery. The animal protocol was approved by the Institutional Animal Care and Usage Committee. After sacrifice, torsional testing was performed on the the bone-prosthetic specimen following complete removal of cement mantles around from the stem [3]. The bone-prosthesis junction torsional stiffness and ultimate torque were determined. Time sequential changes in dynamic weight bearing and radiographic parameters were analyzed by ANOVA with Tukey’s post hoc test. Statistical comparison between the experimental and control sides was performed with a paired student’s t test.

RESULTS: Loosening of the prosthesis was observed radiographically in 2 dogs. One dog had lameness for 2 months after surgery and distal stem loosening was apparent radiographically at 9 weeks after surgery. Other loosening occurred at the proximal stem on the experimental side. These samples were included in the mechanical testing. Fracture was observed radiographically on the proximal femur of one dog at 12 weeks after surgery. The fracture seemed to occur due to overreaming and this animal was excluded from the experiment.

Dynamic Weight Bearing: An initial decrease in dynamic weight bearing was observed on both sides at 4 weeks after surgery, but it was not statistically significant. There were no statistical differences between the experimental side and the control side throughout the experimental periods.

Radiographic Analysis: The total periosteal callus area of both sides increased between 1 and 4 weeks after surgery (p<0.05). On experimental side, significant decrease was observed between 4 and 12 weeks but the callus area at 12 weeks still remained 223% of the original area (p<0.05). On the control side, the callus area decreased to 97% of the original area during the same period (p<0.05). The callus area on the experimental side was significantly larger (p<0.05) than the control side at 2, 4 and 6 weeks after surgery. The total periosteal callus contact surface area of the prosthesis on the experimental side was significantly larger (p<0.05) than on the control side at 4 weeks after surgery.

Mechanical testing: Maximum torque for the experimental side and the control side was 13067±9013 and 6019±3332 Nmm (mean±SD), respectively. Torsional stiffness in the experimental side and the control side was 2085±1278 and 895±613 Nmm/degree, respectively. The mean torsional stiffness was significantly greater on the experimental side (p<0.03). There was a strong trend of greater ultimate torque on the experimental side (p=0.06).

DISCUSSION: OP-1 with collagen type I putty showed an equivalent effect in terms of the functional weight-bearing, torsional properties, and superior new bone formation to the autogenous cancellous bone graft for the EBBI formation using cortical allograft strips. Allograft has been used as an osteoinductive structural strut in skeletal reconstruction and OP-1 has been well demonstrated as an effective osteoinductive factor. A combination of this allograft applying technique and OP-1 with collagen type I putty successfully enhanced the biological fixation of bone and segmental prosthesis, and completely replaced the need of using autogenous bone graft in the procedure.

REFERENCES:

Acknowledgement: Supported by Stryker-Howmedica-Osteonics.