INTRODUCTION Segmental bone loss is a significant clinical problem. While fresh autologous bone graft is the material of choice for reconstructing large defects caused by trauma or tumor resection, the supply of donor bone is limited and graft harvest is associated with substantial morbidity. Alternative strategies for treating segmental bone loss have been numerous and varied.

SIS is an acellular, collagen-based extracellular matrix material derived from the submucosa of porcine small intestine that has been shown to contain bioactive molecules (e.g. bFGF, TGF-β)[6]. In orthopaedic soft-tissue applications it has been explored for use in the repair of ligament[2], tendon[1, 4], and meniscus[3]. The appeal of SIS in these and other applications lies in its ability to promote tissue regeneration.

This study was performed to evaluate the utility of SIS as a graft material for the treatment of segmental bone defects. In particular, critical length osteoperiosteal segmental defects in the rat femur were either left unfilled, filled with ‘autologous’ cancellous bone, or filled with intramedullary tubes or periosteal sleeves fabricated from SIS.

METHODS Unilateral 8.0 mm segmental defects were created in the right femurs of forty-eight male rats and the fragments were stabilized with a miniature external fixator. The animals were divided into four experimental groups. In Group I (n=12) the defect was left unfilled and in Group II (n=12) the defect was filled with cancellous bone from syngeneic donors. In Group III (n=12) the defect was bridged with a small diameter (~2.25mm) tube of SIS inserted into the marrow cavities of the proximal and distal fragments, and in Group IV (n=12) the defect was bridged with a periosteal sleeve (~5mm dia.) of SIS (Figure 1). The intramedullary tubes and periosteal sleeves (furnished by DePuy Orthopaedics, Inc.) were fabricated by wrapping single 15cm-long sheets of SIS around 0.9mm and 6.0mm mandrels, respectively. Sprague Dawley rats were used for Groups I, III and IV, while syngeneic Lewis rats were used for Group II, and as cancellous bone donors.

All of the animals were sacrificed twelve weeks post-operatively. Healing was assessed with biweekly serial radiographs, and at sacrifice with routine histology and torsion testing.

Radiographic Evaluation Lateral plane radiographs of each animal were taken post-operatively, and then biweekly throughout the course of the study. Each x-ray was reviewed for evidence of callus formation, bridging of the distraction gap, and cortical remodeling.

Morphological and Histological Evaluation Twenty-three femurs were evaluated histologically: six each from Groups I, III, and IV, and five from Group II. The femurs were fixed in formalin, demineralized, dehydrated, and embedded in paraffin. Serial 6μm longitudinal sections were cut and stained with either hematoxylin and eosin, Masson’s Trichrome, or Safranin-O/Fast Green.

Mechanical Testing Both femurs from seven animals in Group II were tested to failure in axial torsion with the use of a servohydraulic materials testing machine (none of the defects in the Group I, III or IV animals healed). All of the bones were tested in internal rotation at 5.0 degrees per second over an arc of 30 degrees axial rotation. The raw torque-rotation data was reduced to mean torque (N*deg) and variance. P values were 0.29, 0.99 and 0.03, respectively.

RESULTS Forty-seven animals were available for evaluation at the end of the experiment: one Group I animal died post-operatively due to anesthetic complications. At sacrifice, one animal (Group II) was missing one of the fixator pins and had a deep infection, while in another two pins were loose.

Evaluation of the biweekly radiographs revealed a striking difference in the healing of the animals grafted with autogenous bone (Group II) as compared to the other three groups. At twelve weeks, ten of the twelve animals grafted with cancellous bone appeared to be healed (Figure 2). Of the remaining two, one failed to unite due to the loss of a fixation pin, while the other had a persistent radiolucency traversing the graft. In contrast, there was no evidence of new bone formation in the negative controls (Group I), or in the animals treated with SIS (Groups III and IV).

CONCLUSIONS In contrast to the encouraging results in musculoskeletal soft tissues, and one optimistic prior report of the use of SIS in bone[5], our findings suggest that, in the configurations we tested (intramedullary tubes and periosteal sleeves), porcine SIS is not a useful candidate biomaterial for the treatment of segmental bone defects.

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