INTRODUCTION: Porous tantalum is an elemental metal in a patented structure, which is characterized as about 70 - 80% porous, has an average pore size of 400 to 500 µm with fully interconnected pores (Figure 1) and with stiffness similar to bone [3]. In a canine acetabular model [2], porous tantalum has been demonstrated to be osteoconductive [1] and effective for biological fixation; clinically, it has proved its worth in joint replacement applications [4]. Only a limited amount of research has investigated potential application for the porous tantalum implants in intervertebral spinal fusion. The purpose of the present study was to assess the radiographic and histological performance between porous tantalum implants and the carbon fiber cage in a porcine anterior lumbar interbody fusion (ALIF) model. Our hypothesis was that due to a larger potential for bone ingrowth, the macroporous tantalum implant would match the carbon fiber cages in the anterior interbody site with a potential for improved longevity.

METHODS: Ten 12-week-old female Danish Landrace pigs underwent anterior intervertebral lumbar arthrodeses at L2-3, L4-5 and L6-7. Each level was randomly allocated to one of three implants (Figure 2): a solid piece of porous tantalum (PT-Solid), a porous tantalum ring (PT-Ring) or a carbon fiber cage (CF-Cage). Both the ring and the cage were packed with autograft. Each level was fixed with two staples. The radiographic and histological evaluations were performed three months postoperatively. The experiment complied with the Danish Law on Animal Experiments and was approved by the Danish Ministry of Justice.

Student t-test was used to compare the means of bone graft packed into the hole of the PT-Ring and the CF-Cage. The chi-square test was used for nonparametric values of radiolucenties and gross histology. All histomorphometrical data were expressed as the mean ± standard error of the mean (SEM). The results of bone ingrowth into the holes and pores of implants and implant interface were analyzed using a repeated measure ANOVA. Mann-Whitney test was made for comparing total bone volume in the hole of the PT-Ring or the CF-Cage and the neighbouring vertebral bone. Significance was set at p<0.05. Statistical analysis was performed with SPSS 10.0 software.

RESULTS: Compared to the carbon fiber cage, the tantalum ring has a smaller central hole for bone graft with a corresponding capacity for containing less bone graft within the hole (0.66g vs. 0.99g, p<0.001). While radiolucenties were more frequent around solid tantalum compared to the carbon fiber cage (p = 0.02), there was no difference between the tantalum ring and the carbon fiber cage. The gross histology of the interface between implants and vertebral bone did not demonstrate any difference (Table 1).

Bone ingrowth into the holes of the implants was 39.3 ± 3.3% in the PT-Ring and 52.4 ± 5.2% in the CF-Cage. Bone ingrowth into the pores of porous tantalum was 4.9 ± 1.9% in PT-Solid and 5.9 ± 1.7%. Bone in the implant interface was 39.9 ± 1.7% in the PT-Solid, 37.7 ± 2.2% in the PT-Ring and 42.7 ± 2.4% in the CF-Cage. The bone volume fractions (BVF) were not statistically different in the holes or pores of implants and implant interface.

The vertebral BVF was 35.2 ± 1.3% in the cranial neighbouring vertebral body adjacent to the PT-Ring and 35.3 ± 1.5% in the cranial neighbouring vertebral body adjacent to the CF-Cage. There was no difference in BVF in the hole of the PT-Ring and the neighbouring vertebral bone, but there was significant difference in the hole of the CF-Cage and the neighbouring vertebral bone (p = 0.005).

DISCUSSION: The present study demonstrates that the radiographic and histological appearance of the porous tantalum ring was equivalent to the carbon fiber cage in this porcine ALIF model. Our data show that the porous tantalum ring required less bone graft to achieve results equivalent to the carbon fiber cage. Although the carbon fiber cage with its large central opening and narrow peripheral rim has more bone formation in the hole, the porous tantalum ring with a small central hole and a wide peripheral rim has a BVF similar to the neighbouring vertebral bone. Due to its high porosity and structural stiffness in the relatively low range of about 2.5 to 4.0 GPa [3], it is similar to cancellous bone, a quality which could be advantageous in bone remodelling. More importantly, the new bone ingrowth into the pore of the porous tantalum ring is helpful for long-term biological fixation on porous intervertebral spine fusion devices. The high presence of radiolucent lines around the solid tantalum implant emphasizes the need for a stable biomechanical environment for the achievement of bone ingrowth in this ALIF implant.

ACKNOWLEDGMENTS: The authors are grateful for financial supports from Implex® Corp., NJ, USA, and the Institute of Experimental Clinical Research, University of Aarhus, Aarhus, Denmark. Hdrocel AlIF devices (Porous Tantalum Implants) were manufactured and provided by Implex® Corp., NJ, USA.

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