Fusion Rate Effects of Electron Beam Sterilization on Novel Peptide Amphiphile-Based Spinal Implant

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INTRODUCTION: AMFX-100 is a bone graft substitute, consisting of peptide amphiphiles (PA), polyethylene glycol (PEG), and tri-calcium phosphate (TCP) granules. The device is designed to be implanted into the intervertebral space, inducing the formation of new bone to fuse the vertebrae. Prior to clinical use, AMFX-100 must be end sterilized with a method compliant with Good Manufacturing Practices (GMP). One such method is electron beam irradiation (e-beam), and this study aims to determine if e-beam irradiation impacts the capacity of AMFX-100 to promote spinal fusion.

METHODS: AMFX-100 either was or was not irradiated with 25 kGy e-beam prior to bilateral implantation between the L4-L5 transverse processes of 14 Sprague-Dawley rats (irradiated vs control, n=7). The rats were split into two experimental groups: 25 kGy e-beam irradiated & non-irradiated control. As this is a pilot study, only female rats were used for uniformity in preliminarily estimating the downstream effect of irradiating the implant. Animals were imaged using plain radiography at 4- and 8-weeks post-operation. At 8 weeks, animals were euthanized, and their spines were harvested for assessment of fusion by three blinded reviewers via manual palpation, in which a score of 0 (no bridging bone) or 1 (bridging bone) was assigned. The heart, lungs, spleen, liver, and kidneys of each animal were also harvested and fixed for histology. This study was approved by IACUC.

RESULTS SECTION: Among the rats receiving AMFX-100 without e-beam sterilization, there was a mean fusion score of 1.71, and for the rats receiving AMFX-100 with e-beam sterilization, there was a mean fusion score of 1.86 ($p = 0.53$) (Figure 1A). Successful vertebral fusion was observed in 6 out of the 7 rats without e-beam irradiation (85.71%) and 7 out of the 7 for rats with e-beam (100%) ($p = 0.99$) (Figure 1B).

DISCUSSION: There was no significant difference between the e-beam sterilized AMFX-100 when compared to the non-irradiated control in terms of fusion rate, evidenced by both manual palpation scores and radiological analyses. The results of our study indicate that e-beam irradiated AMFX-100 demonstrated equivalent efficacy in fusion rates when compared to non-irradiated controls.

SIGNIFICANCE/CLINICAL RELEVANCE: By demonstrating that electron beam sterilization preserves the efficacy of AMFX-100, this study supports its potential use as a safe and effective bone graft substitute for spinal fusion procedures while meeting the sterility and safety standards required for clinical translation.

IMAGES AND TABLES:

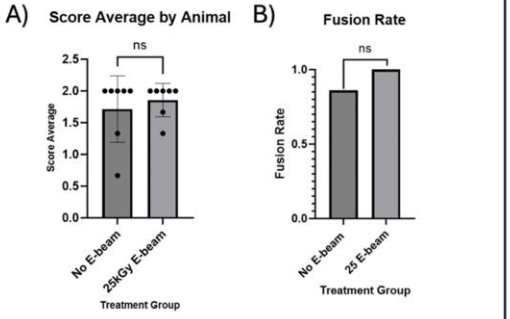

Figure 1. Rat spinal fusion scores assessed by manual palpitation. (A) The scores are the average of three blinded reviewers (0 = judged as unfused; 1 = judged as fused). (B) Fusion considered successful if the average score for each animal is ≥1.

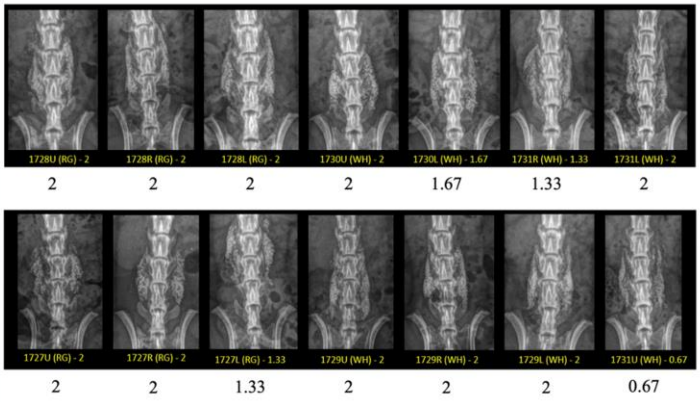

Figure 2. 8-week radiographic images with average fusion score of the experimental group with 25 kGy e-beam sterilization (top row) and control group without e-beam sterilization (bottom row).