The Effect of Aging on Posterior Intertransverse Lumbar Fusion: A New Zealand White Rabbit Model

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INTRODUCTION: The US population is rapidly aging resulting in the number of spinal fusions performed on Medicare beneficiaries over age 65 years to nearly quadruple since 1992.1 While more procedures are being performed in older patients, little is known about the potential effects of aging on lumbar fusion. Increasing age has been reported as a risk factor for delayed and collapsed unions in the thoracic and lumbar spine. Basic information regarding the rate and time of healing, the unique biologic environment, and the biomechanical properties of posterior lumbar fusion in the elderly patient cohort is lacking. Many unique factors affecting lumbar intertransverse fusion have been studied using an established New Zealand white rabbit model.2 Importantly, these studies have utilized skeletally mature young rabbits (6-12 months old), and conclusions drawn from this model may not be valid for translating to the aging human spine.

The purpose of this study was to compare the rate and quality of fusion between a younger and older cohort of New Zealand white rabbits, and to investigate the potential of establishing a translational aged spinal fusion model. It was hypothesized that an increased animal age would negatively affect the rate of successful fusion following a posterior lumbar intertransverse fusion procedure.

METHODS: Ten aged (> 36 months old) and ten young (12 months old) New Zealand white rabbits underwent a single-level, bilateral, L5-6 posterolateral intertransverse fusion using autogenous iliac crest bone graft, using previously published protocols.3,1 The animals were sacrificed at 6 weeks post-operatively, and the specimens were then evaluated with quantitative micro-computerized tomography and manual palpation by six orthopedic surgeons in a blinded fashion. The fusions were graded as either fused or not fused by each examiner. The spines were then embedded in poly(methyl methacrylate) and two-millimeter thick sagittal sections were generated after grinding and polishing.4 Sanderson’s Rapid Bone Stain™ was used for histological analysis.

RESULTS: 17 of the 20 rabbits (9 old and 8 young) survived the perioperative period. With manual testing (Figure 1), a higher percentage of younger rabbits successfully fused (62%) than the old (33%), however the difference was not statistically significant (p=0.35).

Micro-CT analysis (Figure 2) revealed a significantly greater fusion mass volume in the younger rabbits (1934mm3) than in the older cohort (1363mm3), p<0.05. Additionally, the fusion density of the younger rabbits (0.68±0.05) was found to be significantly lower than that of the older rabbits (0.76±0.04, p<0.05) when normalized to the bone density in the non-fused portion of the spine (above the L5-L6 level).

Figure 1: There was a trend toward a higher rate percent of fusion observed in the younger rabbits (62%) compared to the older rabbits (33%, p = 0.35) using manual palpation analysis.

Figure 2: The specimens underwent quantitative micro-computerized tomography with volumetric and density analysis of the fusion mass (Green) performed. A significantly greater fusion mass volume was measured in the younger rabbits than in the older cohort.

Histological analysis showed the presence of vascularized woven bone at the fusion site in both cohorts, however the autograft appeared to be less incorporated by the host in the older animals. Both the young and aged animals exhibited signs of successful remodeling of the autograft bone at the six week time point (Figure 3).

Figure 3: Histological analysis showed the presence of newly formed bone (dark pink) surrounding bone graft tissue (light pink) in both the young and aged animals. Magnification = 10x.

DISCUSSION: The results of this study were consistent with the literature on spinal fusion in the older human population, which has shown higher risk of pseudarthrosis and/or delayed union. The younger rabbits had a significantly greater fusion mass volume than did the older rabbits and a trend toward increased fusion rates. The greater fusion density may be indicative of delayed maturation of the autograft bone in the older rabbits. This suggests a more difficult biological environment for spinal fusion develops with aging. Decreases in successful fusion may impact clinical outcomes, revision surgeries, and cost of care for elderly patients. Additionally, efforts to encourage fusion may be needed in treating aging patients.

SIGNIFICANCE: The New Zealand White rabbit posterior lumbar fusion model appears to be a valid model to evaluate the effects of aging on lumbar fusion. Specifically, the aged (>36 months) New Zealand white rabbit model has potential to more accurately the biologic conditions that are present in the older human population. Further development of this model could aid in investigations to evaluate spine treatment options specific to an elderly population.

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