INTRODUCTION:
Fatigue failure of posterior screw-rod spinal arthrodesis constructs occurs in an average of 6.5% of lumbar arthrodesis cases [1-3]. Substantial surface defects can be introduced via intraoperative contouring using a French Bender to match the natural curvature of the spine [4, 5] and tightening the cap screw to secure the rod to the screw head [4]. Depending on the construct material, these defects ("notches") can significantly reduce the fatigue life of the construct under normal activities of daily living [4, 5]. Titanium (Ti) alloys are highly notch-sensitive as compared to stainless steel (SS); however, other material characteristics of Ti, particularly its high strength-to-weight ratio and MRI compatibility make it an attractive alternative to SS. A previous biomechanical study showed that contouring using a French Bender reduces fatigue life by 62-75% for Ti constructs [5]. Vitallium (Vi), a CoCrMo alloy, has recently been advocated as an alternative to Ti in spinal arthrodesis constructs. This material is fully biocompatible and has been used in orthopaedics applications since 1929, most commonly for hip arthroplasty. Like Ti, it is MRI-compatible and corrosion resistant, but its sensitivity to common intraoperative defects has yet to be investigated. Accordingly, the goal of this study is to evaluate the notch sensitivity of Vi posterior arthrodesis constructs and compare it to Ti and SS.

METHODS:
Lumbar bilateral corpectomy models were constructed based on ASTM F1717-01 using ultra-high molecular weight polyethylene (UHMWPE) blocks as vertebral bodies. Rods 100 mm in length were curved 13-15° at both ends (26-30° total curvature). Three types of constructs were assembled: 1) 5.5 mm SS rods with SS screws (6.5 x 35 mm), 2) 6.0 mm Ti rods with Ti screws (7.5 x 35 mm), and 3) 6.0 mm Vi rods with Ti screws (7.5 x 35 mm). All specimens were tested at 4 Hz in dynamic axial compression-bending with a load ratio of 10 and maximum load levels of 250 N, 400 N, and 700 N.

RESULTS:
The fatigue life of 6.0 mm Vi constructs was statistically equivalent to 5.5 mm SS at all load levels (p>0.05) and greater than Ti constructs at 400 N (p<0.05). Vi constructs sustained 250 N until run-out but failed at high load levels (max. 700 N) at the neck of the Ti screw. At 400 N, most constructs failed (n=8 of 9) at the notch induced by the French Bender. The results of this study indicate that fatigue life of contoured 6.0 mm Vitallium rods is superior to 6.0 mm Ti and comparable to 5.5 mm SS. Like stainless steel, contoured Vi rods can safely sustain the dynamic loads imposed on lumbar arthrodesis constructs during activities of daily living. Walking at a normal cadence induces axial compressive loads on posterior arthrodesis rods of approximately 200 N [6]. For equivalent loading conditions (400 N maximum load level applied to the 2-rod construct), our results indicate that curved Vi constructs sustain 100,000 cycles, which is equivalent to 2 months of normal activity [7]. Our results also show that aggressive physical activity, e.g., jumping or skipping (700 N), can be safely sustained by Vi constructs for up to 10,000 cycles. Failure of Vi specimens for high load levels was most likely to occur in the Ti screws, indicating that fatigue strength may be improved by changing to all-Vitallium constructs.

DISCUSSION:
Our study is the first to evaluate the safety of Vitallium rods in posterior spinal arthrodesis constructs that require intraoperative contouring. We found that curved Vi rods are more fatigue-resistant than Ti rods. Since the static behavior of Vi and Ti is comparable (ultimate compressive stress of 700 MPa vs. 880 MPa, respectively) and both materials are MRI compatible, the results of this study suggest that Vi could be used in place of Ti in posterior arthrodesis constructs that require substantial intraoperative contouring. Comparing Vi to SS, we found that the constructs examined in this study (rod diameters: 5.5 mm SS, 6.0 mm Vi) were equivalent in terms of fatigue life. Before Vi is universally recommended as a safe alternative to SS for curved posterior arthrodesis constructs, future studies should be conducted to compare the fatigue life of these two materials for various common rod diameters and screw configurations.

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