Rod Diameter, Material, and Texture Influence Screw-Rod Fixation Strength in Spinopelvic Constructs

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INTRODUCTION: Spinopelvic fixation is critical in adult spinal deformity surgery, yet mechanical failure rates range from 4.5–38%. Failure often involves the screw–tulip–rod interface, where rod diameter, composition, and surface texture may affect fixation strength. However, the combined biomechanical effects of these variables remain understudied. This study aimed to evaluate the influence of rod diameter, material, and surface texture on axial gripping capacity (AGC) of the screw–rod interface.

METHODS: Axial gripping capacity tests were performed in accordance with ASTM F1798-21 using porous fusion/fixation screws (iFuse Granite, SI-Bone). Rods of 5.5 mm and 6.0 mm diameter were tested in cobalt-chrome (CoCr) and titanium (Ti) with three finishes: grit blast, bead blast, and anodized bead blast. Maximum AGC was defined as the peak load within 1.5 mm of displacement; ultimate AGC (UAGC) within 5 mm. Ten trials per condition were performed. A two-way ANOVA with Bonferroni correction evaluated effects of diameter and material/surface combinations (α=0.05).

RESULTS: Each tested variable significantly affected AGC ($p<0.001$). Independent of material or finish, 6.0 mm rods had significantly higher AGC than 5.5 mm (2518.0 ± 30.9 N vs. 2091.1 ± 30.9 N; $p<0.001$). Among material/finish groups, bead-blasted Ti rods produced the highest AGC (2776.0 ± 61.9 N for 5.5 mm; 2910.3 ± 61.9 N for 6.0 mm), while anodized bead-blast Ti rods yielded the lowest (1656.6 ± 61.9 N and 2076.8 ± 61.9 N, respectively). CoCr grit-blast rods outperformed bead-blast CoCr. UAGC trends mirrored AGC, with minor differences in select comparisons. Pairwise comparisons are in Figures.

DISCUSSION: Rod diameter, material, and surface finish each significantly influenced gripping capacity. Larger diameters consistently improved fixation, but surface finish strongly modulated outcomes within each material. Bead-blasted Ti rods provided the highest fixation strength, while anodized bead-blast Ti rods performed worst. Among CoCr rods, grit-blast outperformed bead-blast, reinforcing that surface texture can alter performance even within a single material class. These findings emphasize that rod selection should consider both size and finish, as optimization at the screw–rod interface may reduce mechanical failure in spinopelvic constructs.

SIGNIFICANCE/CLINICAL RELEVANCE: These findings demonstrate that implant design choices—particularly rod diameter and surface finish—impact the screw–rod interface. Optimizing rod properties may reduce mechanical failure and improve outcomes for patients undergoing spinopelvic fixation.

REFERENCES: 1. Eastlack RK, Spine. 2022;47(14):986-994. 2. Guler UO, Eur Spine J. 2015;24(5):1085-1091. 3. Odland K, Eur Spine J. 2024;33(7):2751-2762. 4. Martin CT, J Neurosurg Spine. 2022;38(1):98-106. 5. Hyun SJ, Oper Neurosurg. 2020;20(1):91-97.

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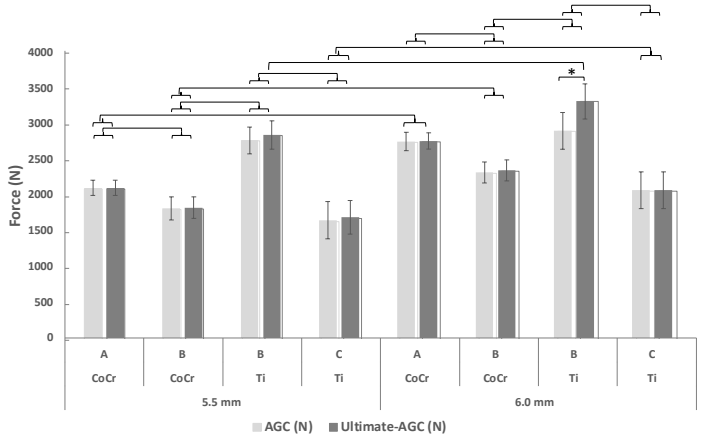

Figure 1: Axial and Ultimate Gripping Capacity (AGC, UAGC). *Eight conditions were tested with variation in rod diameter (5.5 mm, 6.0 mm), material (CoCr, Ti), and surface texture (A: grit-blast; B: bead-blast; C: bead-blast + type 2 anodized). Vertical error bars represent ± standard deviation, and horizontal bars mark statistically significant differences ($\alpha < 0.05$). Comparisons testing for significant difference was performed only between conditions differing by a single parameter.*

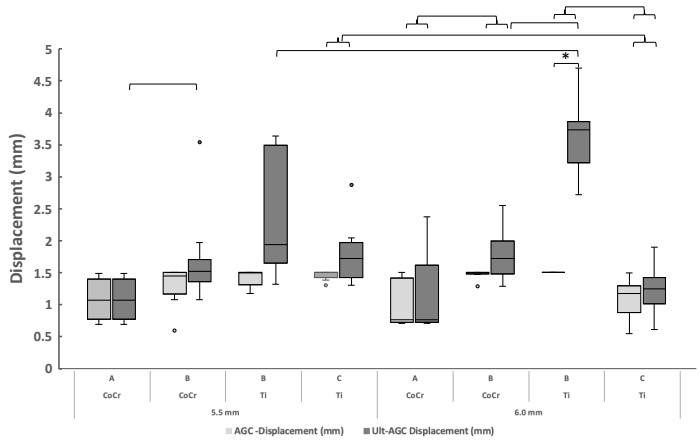

Figure 2. Displacement of Axial and Ultimate Gripping Capacity (AGC, UAG). *Eight conditions that were tested with variation in diameter (5.5 mm and 6.0 mm), material (CoCr and Ti), and surface coating (A: grit-blast, B: bead-blast, C: bead-blast + type 2 anodized). The vertical error bars represent the minimum and maximum values (excluding outliers) and horizontal bars mark statistically significant differences ($\alpha < 0.05$). Comparisons testing for significant difference was performed only between conditions differing by a single parameter.*