The Rogozinski knot: A double suture sliding knot with excellent, biomechanical properties.

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INTRODUCTION: Shoulder surgeons are faced with many, extrinsic and intrinsic variables which may determine the outcome of their soft tissue repair. The most easily controlled variable, the type of knot used, directly affects the integrity of the repair construct. When knots are tied arthroscopically, several problems are can occur including knot slippage and uneven tensioning of the post and wrapping limbs. With each stitch thrown, the surgeon must have confidence that the knot construct has enough loop and knot security to maintain a sound repair. The aim is to distribute loads thus decreasing strain across the repair site. Knots with one suture per loop help distribute forces in the tissue via a self-reinforcing, check rein mechanism. This in effect serves as a rip-stop which affords the excellent biomechanical properties of the knot-tissue complex.

Another way to decrease strain across a repair site is to increase the number of sutures across a given repair site. This may be accomplished using multi-suture loaded, bone anchors such as in a rotator cuff repair model. However, a simpler way of accomplishing this is utilizing a double-suture loop, knot construct. Each loop bears half of the overall force on the repair construct which would theoretically decrease the construct elongation by about one-half (Elongation = FL/AE, where F is force, L is length, A is cross-sectional area, and E is modulus of elasticity). More common repair techniques use sliding knots such as the Weston and SMC knots fo repair, but though with proven knot security, only use a single suture loop.

Objective: The objective was to test the biomechanics of the Rogo knot, [1] double-suture loop, sliding knot construct. The Rogo knot is compared to the Weston[2] and SMC[3] knots as these are two commonly used sliding knots with a long track record of success.

METHODS: ***Knot tying***: Three surgeons of different experience levels participated in the study. A fellowship trained surgeon (FTS), a fellow in training (FIT), and a resident in training (RIT), each surgeon tied 10 knots of each of the knot configurations, Weston, SMC, and Rogo, totaling 30 knots per configuration. All knots were tied over a 25.4mm standardized post to create consistent 25.4mm loops. All knots were tied by hand to minimize suture abrasion or physical obstruction, using #2 FiberWire (Arthrex Inc.).

Biomechanical testing: Similar to previously described techniques, knots were mounted on a material testing machine (Instron E3000 – Instron Corp.) using two parallel rods attached to the actuator and base of the Instron. Positioning the knot between the two rods, a 5N preload was applied to remove any slack from the suture loop. The distance between the two rods was measured after applying the preload (crosshead displacement) and loop circumference was calculated according to the following formula: *loop circumference = 2 x crosshead displacement + 4 x rod radius + rod circumference*. Knots were loaded to failure at a speed of 1mm/sec. Knot failure was defined as 3 mm displacement, knot slippage, or by loop breakage.

Statistical testing: a multiple comparison ANOVA test with Bonferroni correction was used to test knot strength using pooled data from the three surgeons. Furthermore, pooled loop circumference of the three surgeons at 5N preload was used to compare the loop security of the three knots using ANOVA test with Bonferroni correction. The same test was used for intra-surgeon comparison within the same knot for knot strength and loop security.

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Results: ***Knot strength:*** The average strength for all surgeons for the SMC knot was 95.1N ±37.1, and it was 122.5N ±46.4 for the Weston knot. The Rogo knot strength 321.1N ±58.9. The Rogo knot was significantly stronger than both SMC and Weston knots (p<0.0001). The Weston knot also proved to be significantly stronger than the SMC knot (P=0.029), Fig. 1. The three knots didn't show any significant differences in loop security (P>0.05), with the SMC showing a 1.1mm difference in loop circumference after applying the preload, the Weston and the Rogozinski knots showed a 0.98mm and 1.1mm respectively, Fig. 2.

Surgeon variability: There was no significant differences in loop security for all knots combined between surgeons, although the RIT had greater variability in slip and a slightly greater average slip than the FTS and FIT, Fig 3.

Discussion: Our data suggest that there are only minimal differences for the ultimate tensile strength between DBL and ACL, further supporting the claim that demineralized bone has sufficient strength to withstand loading as a ligament

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SIGNIFICANCE: This study presents an objective look at a type of knot that utilizes a double loop to increase the construct strength without theoretically increasing the load on the repair site.

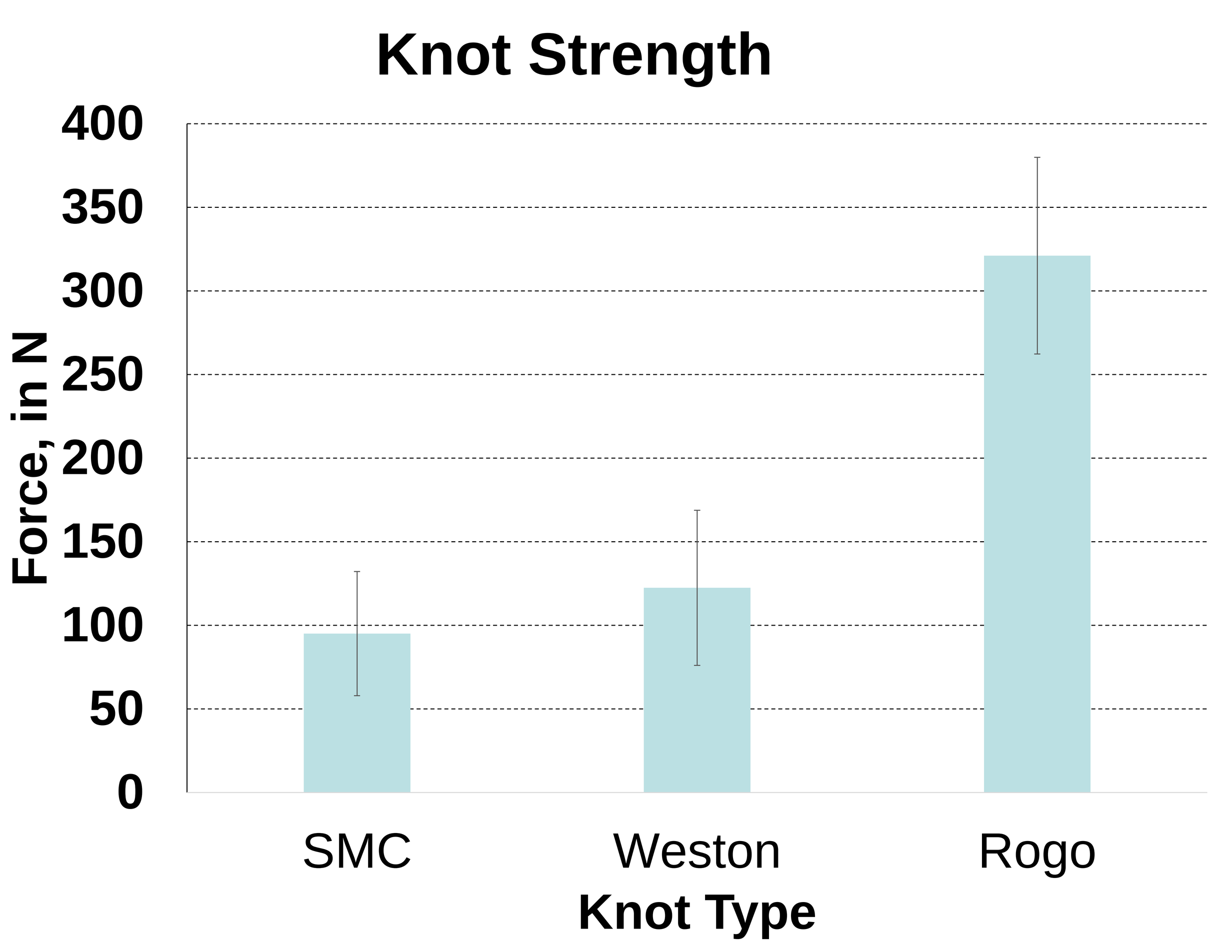

Figure 1 –
Comparison of knot tensile load at 3 mm stretch.

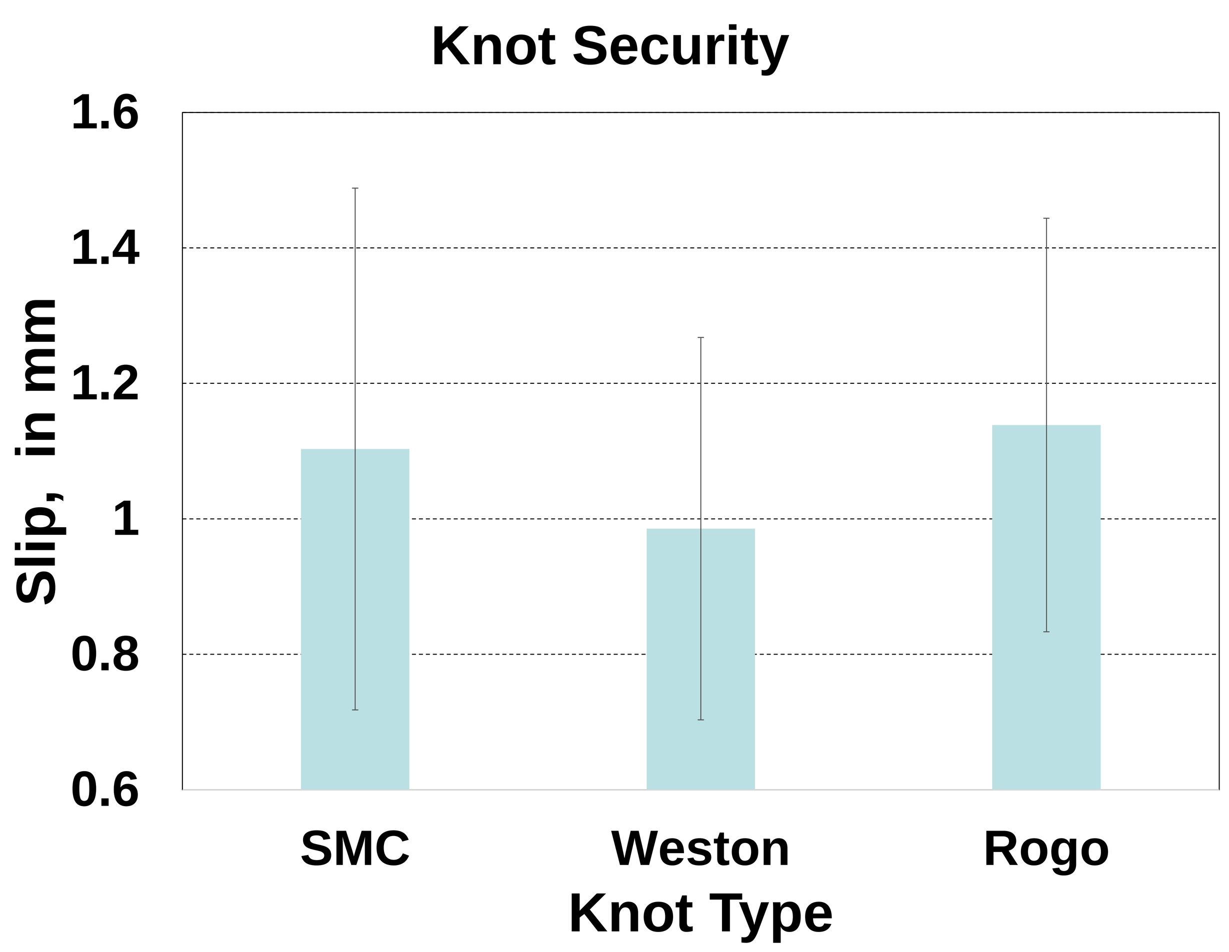

Figure 2 –
Comparison of knot slip at 5 N tensile load

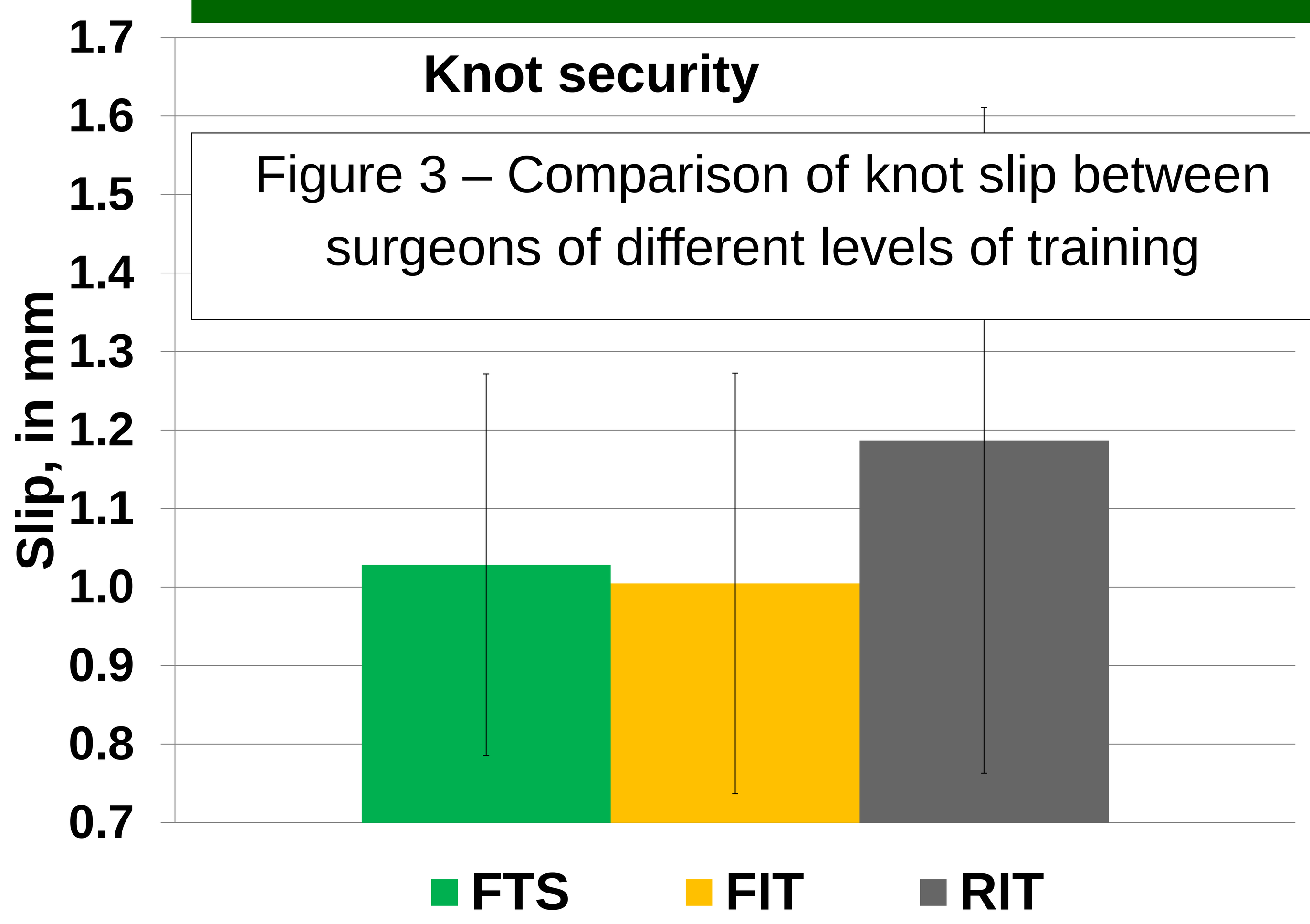

Figure 3 – Comparison of knot slip between surgeons of different levels of training