

Biomechanical Comparison of Y-Knot™ 1.3mm and JuggerKnot™ 1.4mm All-Suture Anchors

Purpose: To compare the biomechanical loading characteristics of the Juggerknot anchor (Biomet Sports Medicine, Warsaw, IN) to the Y-Knot 1.3mm All-Suture Anchor (ConMed Linvatec, Largo, FL) under cyclic loading. **Methods:** 20 suture anchors (12 Y-Knot and 8 Juggerknot anchors) were tested in 40/12.5 PCF foam bone using an MTS Synergie 810 Materials Test System. The anchors were cycled 4000 times between 10N and 43N at 1Hz. Displacement was measured at the completion of the cycles. Defining anchor characteristics, such as anchor construct, implantation technique, pilot hole dimensions, and suture size were noted. **Results:** The Y-Knot All-Suture Anchor recorded an average displacement of 0.86mm compared to 1.19mm for the JuggerKnot anchor. The Y-Knot anchor exhibits other favorable characteristics, such as a smaller diameter pilot hole, a simple pull-to-set deployment technique, a more clinically prevalent suture size (#2 vs. #1), and a shallower drill depth (19mm vs. 23mm). **Conclusions:** The JuggerKnot exhibited over 35% more creep than the Y-Knot anchor in cyclic testing on average, posing a higher risk of clinical failure due to possible gap formation between the labrum and healing surface.

Pull-out strength is a metric often considered by surgeons in selecting a suture anchor. It has been shown that both the JuggerKnot and Y-Knot anchors exhibit pull-out strength exceeding those published for 3.0mm press-fit solid anchors in porcine femur. Specifically, Dr. Barber has published that the Y-Knot 1.3mm exhibits 250N of pull-out strength in porcine bone and the Juggerknot 1.4mm anchor exhibits 239N of pull-out strength. This is compared to pull-out strengths reported in porcine bone ranging from 160N to 175N for SutureTak (Arthrex, Naples, FL), Bioraptor (Smith & Nephew, Andover, MA), and Gryphon (Mitek, Raynam, MA) anchors.^{1,2,3}

While the pull-out strength compares favorably to conventional press fit anchors, the flexible nature of the all-suture constructs of the Y-Knot and JuggerKnot anchors also calls into question stability under cyclic loading. It has been noted that complete pull-out is not necessary for the refixation of soft tissue to bone to fall short of what is desired as a surgical outcome. Specifically, if the anchor creeps toward the bone surface, the repair construct will loosen, which may lead to gap formation between the labrum and bone, thus preventing adequate healing.⁴ This study examines creep under cyclic loading between the Juggerknot and Y-Knot anchors.

Methods

Anchor Description

The anchors evaluated in this biomechanical comparison are pictured in Figure 1. Both the Y-Knot anchor and JuggerKnot are comprised entirely of suture material. The Y-Knot anchor body is made of a 3mm by 25mm flat braid of Ultra High Molecular Weight Polyethelene (UHMWPE) tape. A single strand of number two (#2) HiFi® suture is threaded through six equally spaced piercings in the anchor body. The anchor body is then folded back on itself, and inserted between two tines of an anchor inserter.

The Juggerknot has an anchor body comprised of an 18mm long number five (#5) polyester tube. A single strand of number one (#1) MaxBraid™ suture is threaded through the central portion of the lumen of the anchor body tube, and the anchor is similarly folded back on itself and inserted between two tines of an anchor inserter.

Both anchors are inserted into pilot holes drilled into bone stock, then deployed within the pilot hole by drawing back on the ends of the suture strand to fold the anchor body up in a unique fashion. The result is a reconfiguration of the anchor construct such that it becomes wider than the pilot hole in at least one dimension to achieve fixation within the bone.

The basic aspects of these anchor repair systems are outlined in Table 1.

| | Y-Knot™ 1.3mm | Juggerknot™ 1.4mm |
|----------------------------------|-----------------------|--------------------------|
| Anchor Material | Polyethylene (UHMWPE) | Polyester |
| Anchor Construct | 25mm x 3mm flat braid | #5 Tube |
| High Strength Suture Size | #2 | #1 |
| Pilot Hole Diameter | 1.3mm | 1.4mm |
| Drill Depth | 19mm | 23mm |
| Mass | 12.4mg | 10.0mg |
| Pull-out Strength ^{1,2} | 250N | 239N |



Figure 1: Y-Knot 1.3mm All-Suture Anchor (top) and JuggerKnot 1.4mm soft suture anchor (bottom)

Table 1: Y-Knot 1.3mm anchor and JuggerKnot 1.4mm anchor characteristics

Test Procedure

Eight (8) single-loaded Juggerknot anchors (ref. 912030) and twelve (12) single-loaded Y-Knot anchors (ref. HF13) were tested in foam bone (40/12.5pcf, 1" x 1" x 1") using an MTS Synergie 810 Materials Test System.

The upper and lower fixtures were loaded onto the MTS 810 Material Tester in a manner that permitted loading at a 45° position (Figure 2). This setup replicates the 'Dead Man's Angle' utilized clinically for maximal anchor stability.

Each anchor was inserted into the foam block via manufacturer's surgical technique, and the foam block was loaded into the custom fixture. The anchor's suture was attached to the upper hook/dowel pin by tying a square knot followed by three alternating half hitches. Spacing between the upper and lower fixture was adjusted to achieve a gauge length of 2-3 inches (Fig. 2).

The construct was preconditioned by loading to 60N, holding for 5 seconds and then back down to 10N. This cycling was repeated five (5) times, and the displacement measurement channel was zeroed.

The foam block-anchor construct was loaded under force control between 10N and 43N at a frequency of 1 Hz for a total of 4000 cycles with data acquisition set to 10 Hz. Displacement was measured at the completion of the cycles.

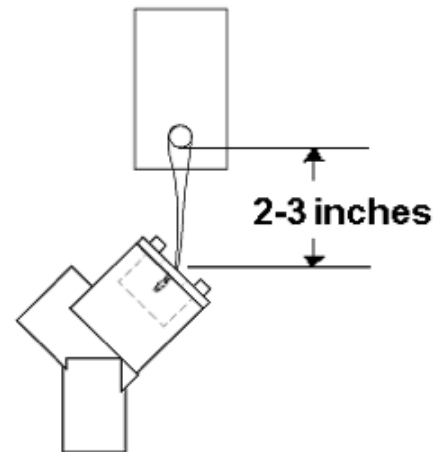


Figure 2: Load Testing configuration

Results

Both the Juggerknot™ and the Y-Knot™ anchors inserted successfully and completed the cyclic testing portion of the procedure without becoming dislodged from the foam block.

The average displacement, or “creep” of the Y-Knot anchors following the 4000 cycles was 0.86mm, whereas the average creep for the JuggerKnot anchors was 1.19mm, which is 35% higher than that observed in the Y-Knot anchor testing. These results are depicted in Figure 3.

Figure 4 shows representative cross-sectioned foam blocks following testing of Y-Knot™ and JuggerKnot™ anchors. Of note, the JuggerKnot anchor on the right has migrated past the cortical threshold, whereas the Y-Knot anchor remains below the cortical threshold.

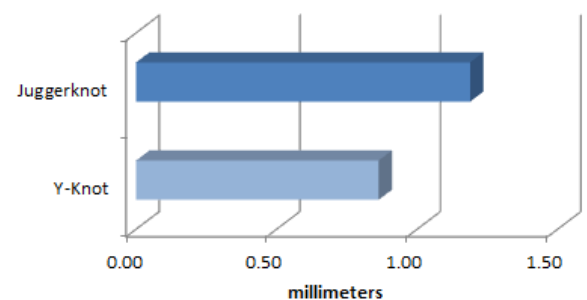


Figure 3: Displacement (creep) following cyclic loading

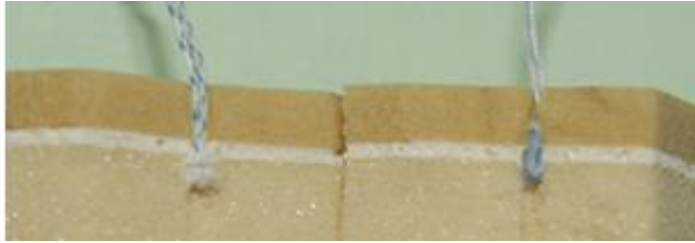


Figure 4: Cross-sectioned foam blocks illustrating creep produced via mechanical loading

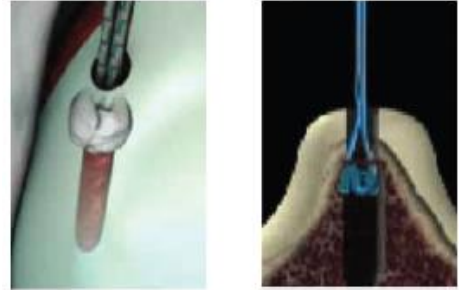


Figure 5: Depictions of Y-Knot™ 360° FormFit™ Fixation and Juggerknot™ ‘W Shape’ Deployment

Discussion

The Y-Knot anchor outperformed the JuggerKnot with respect to displacement under cyclic loading. This could be attributed to a number of factors.

The Y-Knot™ anchor’s Ultra High Molecular Weight Polyethylene flat-braided suture anchor body has 21% more mass than the JuggerKnot’s polyester tube design. This combined with the fact that the Y-Knot anchor is being inserted into a 1.3mm bone hole, versus a 1.4mm JuggerKnot bone hole results in 40% more material for fixation per square millimeter of pilot hole cross-sectional area.

Another possible contributing factor to the reduction in cyclic displacement is the circumferential contact of the Y-Knot anchor when deployed in the pilot hole. The UHMWPE flat braid of the Y-Knot anchor conforms to make contact around the entire circumference of the pilot hole. The JuggerKnot’s polyester tube design is less compliant and does not conform to the pilot hole but rather creates more of a point contact (see *Figure 6*)

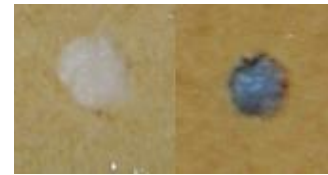


Figure 6: Circumferential pilot hole contact of Y-Knot anchor (left) compared to Juggerknot (right)

Conclusions

The Y-Knot anchor outperforms the JuggerKnot when it comes to displacement under cyclic loading, or creep. The JuggerKnot exhibited over 35% more creep than the Y-Knot anchor in cyclic testing on average, posing a higher risk of clinical failure due to possible gap formation between the labrum and healing surface.

In a recent *Journal of Arthroscopy* publication, JuggerKnot pull-out results were shown to be on par with, if not better than, conventional 3.0mm press-fit anchors. Testing in foam bone showed no significant difference in pull-out strength between the JuggerKnot anchor and Y-Knot 1.3mm All-Suture Anchor.

The Y-Knot exhibits other favorable characteristics, such as a smaller diameter pilot hole, a simple pull-to-set deployment technique, a more clinically prevalent suture size (#2 vs. #1), and a shallower drill depth (19mm vs. 23mm).

References

¹ Barber, FA. et al. Cyclic Loading Biomechanical Analysis of the Pullout Strengths of Rotator Cuff and Glenoid Anchors: 2013 Update. *Arthroscopy*. 2013; 29:832-844.

² Barber, FA. et al. Biomechanical Analysis of Pullout Strengths of Rotator Cuff and Glenoid Anchors: 2011 Update. *Arthroscopy*. 2011; 27:895-905.

³ Barber, FA. et al. Suture Anchor Materials, Eyelets, and Designs: 2008 Update. *Arthroscopy*. 2008; 24:895-867.

⁴ Brown, Barrett S, et al. Initial Fixation and Cyclic Loading Stability of Knotless Suture Anchors for Rotator Cuff Repair. *Journal of Shoulder and Elbow Surgery* 2008.

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