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# Rotator cuff tendon tissue cut-through comparison between 2 high–tensile strength sutures

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**Background:** High–tensile strength sutures are known to cut through tendon tissue when used for rotator cuff and other tendon repairs, resulting in mechanical failure. The purpose of this study was to test a new suture and compare it with an established suture in a controlled laboratory setting.
**Methods:** Two sutures, Dynacord and FiberWire, both USP size No. 2, were passed through fresh infraspinatus tendons from 7 matched pairs of ovine shoulders (14 shoulders). Samples underwent cyclic testing for 1000 cycles, and the amount of cheese-wire tissue damage (tendon cut-through) was recorded. A clinical failure was defined as greater than 5 mm of tissue cut-through.
**Results:** The mean amount of tendon cut-through was 3.72 ± 1.14 mm in the FiberWire specimens and 2.69 ± 1.02 mm in the Dynacord group. The difference was statistically significant ($P = .012$). In the matched-pair analysis, more tendon cut-through was noted with FiberWire in 13 specimens whereas a greater amount was found in only 1 Dynacord specimen. The FiberWire specimens showed 2 instances of tissue tendon cut-through exceeding 5 mm, defined as a clinical failure.
**Conclusions:** In this cadaveric ovine rotator cuff tendon model, we found less tendon cut-through from Dynacord suture compared with FiberWire. In addition, 2 of the FiberWire specimens showed complete tendon cut-through. Future studies focusing on patient-reported outcomes and healing rates with different types of suture materials are needed.
**Level of evidence:** Basic Science Study; Biomechanics


**Keywords:** Tissue cut-through; FiberWire; Dynacord; rotator cuff tear; suture choice; biomechanics

Although rotator cuff repair is a commonly performed procedure, the mechanical failure rate remains high.[7,14] Analysis of failures suggests that, often, the weakest link is the suture-tissue interface.[3,9] Whereas high–tensile strength sutures provide a strong suture construct, they are known to cut through tendon tissue, resulting in mechanical failure. Previous cadaveric studies have shown ''cheese wiring'' (tendon cut-through) of high–tensile strength sutures through tendon tissue, with different sutures showing different performance profiles.[10]

Limiting suture cut-through via cheese wiring is important clinically, especially when considering rotator

Institutional review board approval was not required for this basic science study.

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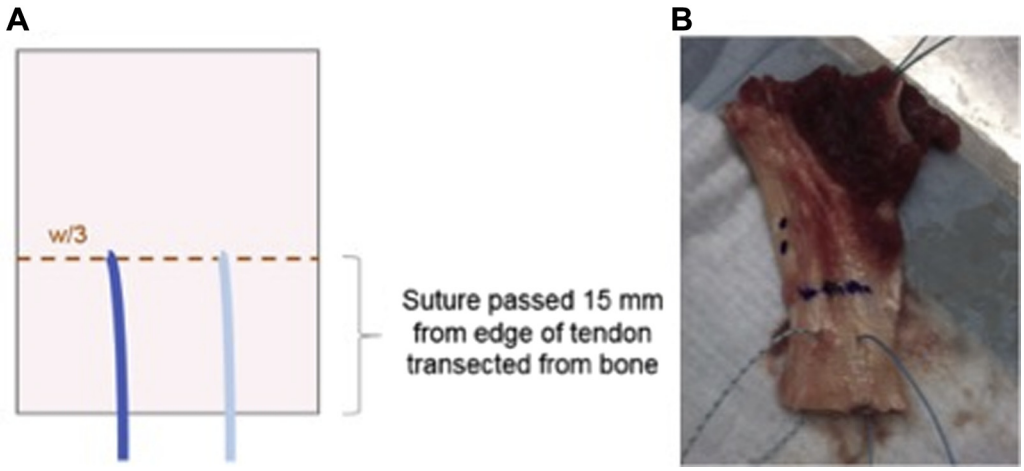


**Figure 1** (**A** and **B**) Placement of suture in infraspinatus tendon. *W,* width.

cuff tissue of poorer quality or in the case of partial repairs, in which surgeons are relying on force-couple restoration to improve the patient's pain and weakness. Dynacord suture (DePuy Mitek, Raynham, MA, USA) is an orthopedic suture that incorporates a silicone/salt-filled core within an ultrahigh-molecular-weight polyethylene (UHMWPE) sheath. The silicone core hydrates in an aqueous environment, causing the core to expand radially. This results in an approximate 10% axial shortening of the suture length. The Dynacord mode of action provides the theoretical advantage of reducing the inherent laxity or creep present in tendon repair constructs at the time of knot tying or anchor fixation.

The purpose of this study was to test a new suture and compare it with an established suture in a controlled laboratory setting. It was hypothesized that no difference would be seen between the suture types.

## Methods

A controlled laboratory experiment was performed comparing the new and established high–tensile strength sutures. The suture in the experimental group was Dynacord, which is composed of a silicone/salt (sodium chloride)–filled core within a UHMWPE sheath. The control suture was FiberWire (Arthrex, Naples, FL, USA), which is a high–tensile strength suture consisting of a multistrand, long-chain UHMWPE core with a braided jacket of polyester and UHMWPE, commonly used in orthopedic applications including rotator cuff repair.[1] USP size No. 2 suture was used in both groups. Both sutures were pre-hydrated by soaking them in normal saline solution for 48 hours prior to testing.

Fresh infraspinatus tendons from 7 matched pairs of ovine shoulders (14 shoulders) were used. The infraspinatus tendon was sharply dissected from its insertion on the humerus with a No. 10 blade. The muscle was also removed. The tendon width and thickness at the site of suture passage were measured with digital calipers and recorded. Both sutures were passed through the tendon 15 mm from its distal end using an Expressew 3 Autocapture shuttling device (DePuy Mitek) that was maximally medialized (hubbed) on the tendon. The sutures were each shuttled in the tendon at the junction of the superior and inferior thirds (approximately 7 mm from the tendon edge), ensuring equal spacing of the sutures within the tendon (Fig. 1). Both suture types were passed in each specimen to minimize the impact of specimen variability. The cranial and caudal positions of each suture were alternated within each matched specimen pair.

The proximal tendon end was secured in the upper clamp, and 1 suture was secured in the lower clamp. The specimen was secured in the upper grip such that 25 mm of tendon was exposed. The grips on the Instron machine (Instron, Norwood, MA, USA) were adjusted such that the gauge length between grips was 35 mm (Fig. 2). The clamps were secured to an Instron 8521S servohydraulic test frame. The sutures were tested one at a time. The tendon-suture construct was preloaded with a 5-N load for 5 seconds. Cyclic testing for 1 of the paired sutures was performed with ramp to 50 N for 5 seconds and with ramp down to 30 N for 5 seconds, followed by a cycle from 10 to 50 N for 1000 cycles, at a frequency of 1 Hz. After this test was complete, the second suture within the same tendon was loaded and the aforementioned protocol was repeated. After completion of loading for both sutures, the specimen was removed from the grips and the tendon cut-through length (cheese-wire distance) was recorded with a digital caliper for each suture. With a high-resolution camera, images of the tendon cut-through distance were captured (Fig. 3). It was determined that 5 mm of tissue pull-through would indicate a clinical failure based on accepted clinical practice.[5,7]

### Statistical analysis

Data were recorded in Microsoft Excel (Microsoft, Redmond, WA, USA). In addition to baseline specimen measurements including the tendon width and thickness, the average distances of cheese wiring for each cohort were calculated. A matched-paired *t* test was used to compare the 2 suture materials for soft-tissue cut-through. Statistical significance was set at $P < .05$.

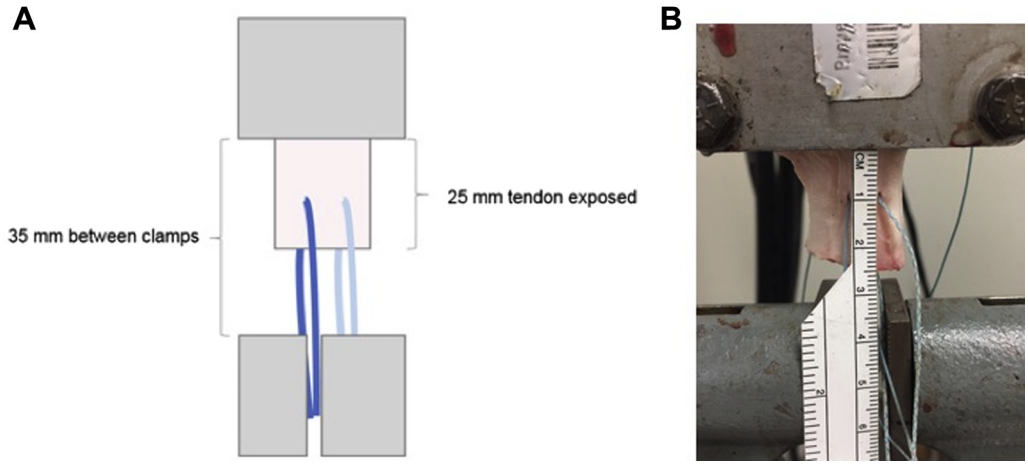


**Figure 2** Diagram (**A**) and photograph (**B**) of specimen loaded into Instron machine.

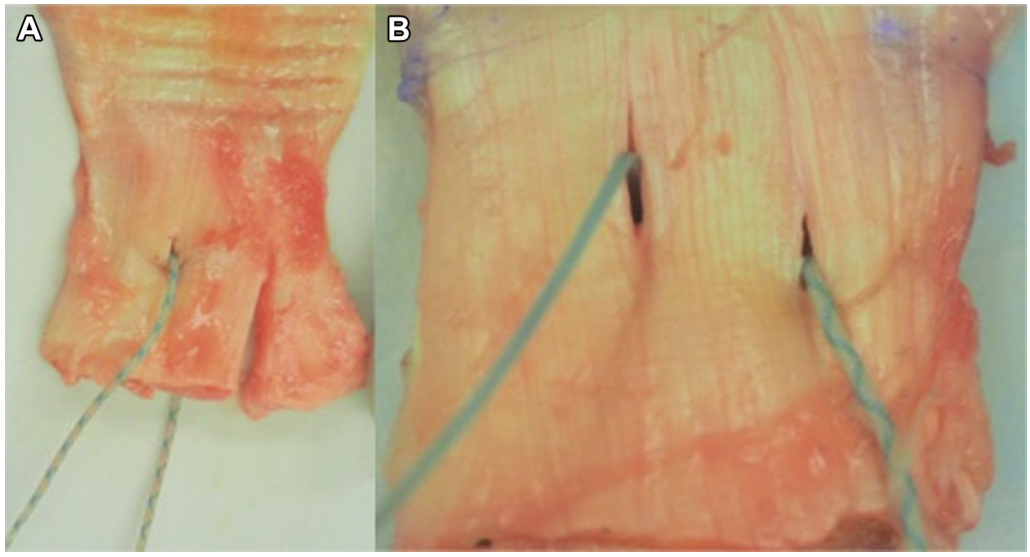


**Figure 3** Cheese-wire tissue damage. The FiberWire suture (*blue*) completely pulled through 2 specimens (**A**) and showed a greater amount of tissue damage (**B**).

## Results

No significant differences in either the width or thickness of the tested specimens were noted between pairs (Table I). The cranial portion of the tendon was thicker than the caudal portion, thus necessitating the alternation of the sutures being passed at each location.

Significant differences in tissue failure at the interface were noted with each suture. The FiberWire specimens showed 2 instances of tendon cut-through exceeding 5 mm—the point determined to represent a clinical failure (Table II). No failures were seen in the Dynacord group. The mean amount of tendon cut-through was 3.72 ± 1.14 mm in the FiberWire specimens and 2.69 ± 1.02 mm in the Dynacord group. A matched-pair *t* test showed a statistical difference ($P = .012$) in favor of Dynacord suture. In the matched-pair analysis, more tendon cut-through was noted with FiberWire in 13 specimens whereas a greater amount with Dynacord occurred in only 1 specimen (Fig. 4).

## Discussion

This study found that cheese wiring was decreased when using Dynacord suture compared with FiberWire suture in 13 of 14 specimens. The average amount of tendon cut-through was statistically significant, with FiberWire specimens experiencing 3.72 mm compared with 2.69 mm in the Dynacord group. In addition, 2 FiberWire specimens cut through the tendon by greater than 5 mm, which signified the

**Table I** Tendon width and thickness

| Specimen No. | Tendon width, mm | Tendon thickness, mm | |
|---|---|---|---|
| | | Cranial | Caudal |
| 1 | | | |
| R | 19.21 | 4.23 | 2.64 |
| L | 19.43 | 4.55 | 2.52 |
| 2 | | | |
| R | 22.41 | 4.81 | 3.11 |
| L | 22.03 | 4.52 | 3.34 |
| 3 | | | |
| R | 21.53 | 5.28 | 3.56 |
| L | 22.06 | 5.05 | 3.12 |
| 4 | | | |
| R | 23.21 | 4.91 | 4.85 |
| L | 23.24 | 5.65 | 4.21 |
| 5 | | | |
| R | 23.62 | 6.05 | 4.41 |
| L | 24.06 | 7.75 | 5.05 |
| 6 | | | |
| R | 22.16 | 4.43 | 4.03 |
| L | 24.16 | 4.39 | 3.94 |
| 7 | | | |
| R | 22.47 | 4.61 | 4.36 |
| L | 25.70 | 4.69 | 4.41 |

*R*, right; *L*, left.

**Table II** Amount of cheese-wire damage seen in matched specimens

| | Cut-through distance | |
|---|---|---|
| | FiberWire | Dynacord |
| Sample 1717, mm | | |
| Cranial | 2.59 | 1.41 |
| Caudal | 3.03 | 2.48 |
| Sample 1716, mm | | |
| Cranial | 3.13 | 1.31 |
| Caudal | 2.05 | 1.82 |
| Sample 1714, mm | | |
| Cranial | 3.67 | 2.34 |
| Caudal | 1.59 | 4.01 |
| Sample 1801, mm | | |
| Cranial | 5.00 | 1.68 |
| Caudal | 3.24 | 2.73 |
| Sample 1802, mm | | |
| Cranial | 5.00 | 4.32 |
| Caudal | 4.20 | 2.13 |
| Sample 1810, mm | | |
| Cranial | 4.67 | 4.01 |
| Caudal | 4.93 | 3.09 |
| Sample 1803, mm | | |
| Cranial | 4.71 | 2.53 |
| Caudal | 4.24 | 3.83 |
| Average, mm | 3.72* | 2.69* |
| SD, mm | 1.14 | 1.02 |
| 95% CI, mm | 3.06-4.37 | 2.10-3.28 |
| Range, mm | 3.41 | 3.01 |
| No. of samples | 14 | 14 |

*SD*, standard deviation; *CI*, confidence interval.
* $P = .012$.

equivalent of a clinical failure. These results signify that the amount of soft-tissue cut-through produced in an ovine infraspinatus tendon by Dynacord suture in a laboratory setting is significantly less than that produced by FiberWire.

Lambrechts et al[10] performed a similar study examining cheese wiring of 3 different suture materials: No. 2 Orthocord suture (DePuy Mitek), No. 2 Ethibond Excel suture (Ethicon, Somerville, NJ, USA), and No. 2 FiberWire suture. They tested the sutures via cyclic loading in 12 cadaveric shoulders and reported mean cut-through values of 2.9 ± 0.6 mm for No. 2 Orthocord suture, 3.2 ± 1.2 mm for No. 2 Ethibond suture, and 4.2 ± 1.7 mm for No. 2 FiberWire suture. Our study similarly showed a greater cut-through distance with FiberWire, albeit with an average distance of 3.72 mm compared with 4.2 mm. Lambrechts et al postulated that both a lower coefficient of friction and greater stiffness were responsible for greater cut-through, specifically with FiberWire.

Silva et al[12] examined the coefficient of friction of FiberWire to nylon enclosed in a smooth nylon outer shell (Supramid; S. Jackson, Alexandria, VA, USA), and No. 3-0 braided polyester coated with polybutilate. FiberWire had the lowest coefficient of friction (0.054) of the 3 sutures investigated; however, it showed similar repair strength to the other sutures. Although this lower coefficient of friction may increase the ease of suture passage and subsequent tying, it also appears to make it easier for the suture to cut through the tissue after repair, as shown in our study, as well as that of Lambrechts et al.[10] Stiffness may also play a role in the mechanical properties of rotator cuff repair regarding clinical failure and soft-tissue cut-through. Najibi et al[11] performed mechanical testing of 11 common suture materials (3 braided nonabsorbable suture materials and 1 braided absorbable suture material with different calibers) used in orthopedic surgery. FiberWire had both the highest maximum load to failure and the highest stiffness. The combination of high stiffness and a low coefficient of friction may contribute to the degree of cheese wiring shown in our study and that of Lambrechts et al.

In addition, the aforementioned study by Najibi et al[11] showed that the most common site of suture failure was at the knot. The structure of Dynacord offers protection from this mode of failure. The suture material has a silicone core, which shortens in an aqueous environment, resulting in an approximate 10% decrease in the suture length. This provides the theoretical advantage of reducing the inherent creep present in a tendon repair construct at the time of knot tying or anchor fixation. This has the potential to minimize cheese-wire tissue damage as well as

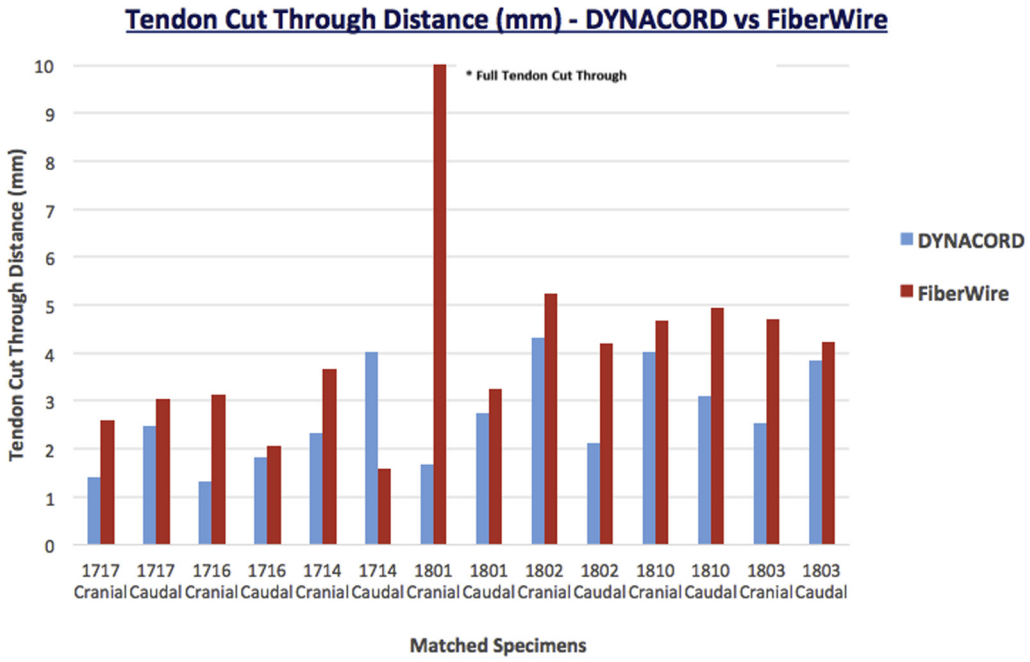


**Figure 4** Amount of tendon cut-through damage in FiberWire vs. Dynacord specimens. More damage was seen with FiberWire suture in 13 of 14 specimens.

failure at the knot interface. In addition, in the hydrated state of Dynacord, the diameter of the suture increases.[4] This increase in diameter increases the contact area between the tendon and suture, thus reducing the pressure applied locally. Moreover, the hydrated silicone core will compress when a load is applied, allowing the suture to absorb the force applied through the suture-tendon interface.[4]

Cheese wiring, or tendon cut-through, is one of the many modes of failure possible after rotator cuff repair. With the rise in the popularity of arthroscopic rotator cuff repair and the ability to perform it, several techniques have been developed to minimize suture cut-through. Use of a double-row, transosseous-equivalent suture anchor configuration has been shown to better distribute stress placed on the repaired tendon and minimize suture cut-through.[2,8] In addition, the use of ''suture tapes'' with a wider cross-sectional area (2 mm) than suture has been thought to lower the risk of tendon cut-through.[13] Another important factor to consider is the distance at which the suture is passed from the edge of the tendon. Hapa et al[6] performed a mechanical study in which suture configurations were tested to failure to examine the role of suture bite size (distance from the tendon edge) and the width in the bites of a mattress stitch to see which had a greater influence on failure. They found that bite size was the more important factor, with specimens in which the suture was passed just 5 mm from the edge of the tendon almost exclusively failing as a result of cut-through as opposed to other modes of failure (suture breakage, tendon tear). Clinically, this finding is relevant, especially for retracted tears with poor-quality tissue. In our study, none of the Dynacord specimens exhibited 5 mm of cut-through, as opposed to 2 FiberWire specimens.

This study has several limitations. First, it was a mechanical study using ovine tissue, which is not equivalent to human tissue. Second, it was a time-zero cadaveric mechanical study and does not reflect the performance in a healing environment. Third, this study was not performed in an aqueous environment. In addition, the stress applied by the suture to the tendon was not a pulling of the suture through the tissue, as might occur while tying a sliding-locking knot. As in any cadaveric study, the number of specimens available was limited, and no power analysis was performed prior to this study; rather, the sample size was based on similar studies in the literature.[10,11] Last, the knots were not tied, and no assessment of knot performance of the individual suture types was performed. Despite these limitations, this study provides useful information for surgeons performing tendon repair using the sutures and devices tested.

## Conclusion

In this cadaveric ovine rotator cuff tendon model, we found less tendon cut-through from Dynacord suture compared with FiberWire. In addition, 2 of the FiberWire specimens showed complete tendon cut-through. Future studies focusing on patient-reported

outcomes and healing rates with different types of suture materials are needed.

## Disclaimer

This project was funded by DePuy Synthes Mitek Sports Medicine and performed at Rhode Island Hospital. DePuy Mitek had final say over the publication of this article.

Brett D. Owens is a consultant for Mitek and MTF/ConMed. All the other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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