The Properties of Damaged and Undamaged Suture Used in Metal and Bioabsorbable Anchors: An In Vitro Study

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Purpose: The purpose of this study was to determine the mechanical properties of undamaged and damaged sutures in metal and bioabsorbable suture anchors. **Methods:** Undamaged and damaged FiberWire (Arthrex, Naples, FL), Tevdek (Deknatel, Mansfield, MA), and PDS (Ethicon, Somerville, NJ) sutures were tested by a single pull to failure while being pulled parallel to the axis of either a metal or bioabsorbable suture anchor. Sutures were damaged by use of a razor blade incorporated into a custom-designed jig. The friction of the sutures through the anchor eyelets was also tested. **Results:** For both anchor types, FiberWire was the strongest suture studied. Undamaged PDS had a significantly greater load to failure than Tevdek. Although all sutures lost significant strength when damaged, PDS lost the most, with damaged PDS becoming significantly weaker than damaged Tevdek. Damaged FiberWire was significantly stronger in metal anchors compared with bioabsorbable anchors, with failure of the bioabsorbable suture eyelet preventing testing of undamaged FiberWire. Neither undamaged nor damaged PDS or Tevdek had a significant difference in strength between metal and bioabsorbable anchors. However, in metal anchors the mechanical properties of undamaged Tevdek were inferior to those of the other undamaged sutures tested. For undamaged or damaged sutures through either anchor type, PDS suture had the highest coefficient of friction, significantly higher than FiberWire and Tevdek. All sutures, undamaged or damaged, had significantly less friction in bioabsorbable anchors compared with metal anchors. **Conclusions:** The FiberWire-anchor construct is significantly weaker when bioabsorbable anchors are used instead of metal anchors. For Tevdek and PDS sutures, the anchor type does not affect the strength of the construct, as the suture is the limiting factor. When used with suture anchors, PDS has the most friction of the sutures tested, potentially leading to suture damage, which disproportionately weakens PDS compared with the other sutures tested. For both undamaged and damaged sutures, bioabsorbable anchors lead to less friction than do metal anchors, which may lessen suture damage in vivo. **Clinical Relevance:** The mechanical properties of damaged suture are important to all surgeons who use suture arthroscopically. **Key Words:** Suture—Damage—Biomechanics—Suture anchor.

Sutures are an integral part of arthroscopic shoulder repairs and reconstructions. Especially in the shoulder, they are routinely passed through and alongside sharp instruments that may damage them. In addition, they are routinely used in conjunction with suture anchors, which may be composed of either metal or a bioabsorbable polymer. The in vivo environment exposes the suture to cyclic loading and abrasion against the anchor's eyelet during arthroscopic knot tying and during early postoperative rehabilitation.[1] The properties of damaged suture have been examined.[2] The influence of the type of anchor on suture/anchor friction, which is a factor in the occurrence and propagation of suture damage, as well as on the mechanical properties of the suture once damaged, is important for the arthroscopic surgeon to

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The authors report no conflict of interest.

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0749-8063/07/2306-6357$32.00/0
doi:10.1016/j.arthro.2007.01.008

be aware of when deciding on his or her choice of suture or anchor. The purpose of this study was to determine the mechanical properties of undamaged and damaged sutures in metal and bioabsorbable suture anchors. The null hypothesis is that there is no significant difference in mechanical properties for any of the conditions tested.

METHODS

Three types of suture were tested: Tevdek (Deknatel, Mansfield, MA), FiberWire (Arthrex, Naples, FL), and PDS (Ethicon, Somerville, NJ). The anchors used were the metal Arthrex 5.0-mm Corkscrew and the bioabsorbable Arthrex 5.0-mm Bio-Corkscrew. Similar to other studies,[2,3] preliminary testing did not show differences in failure behavior between dry and wet suture material. Therefore, to be consistent with previous studies,[1-5] testing of all sutures was performed dry at room temperature. The manufacturers have indicated that the difference between room and body temperature would be too small to make a significant difference in the biomechanical properties of the sutures.

Twenty-four sutures of each type were used for the load-to-failure/failure stress test; 12 were used with metal anchors and 12 with bioabsorbable anchors. Each of these groups was subdivided into 6 sutures to be tested undamaged and 6 to be tested damaged. To simulate potential damage incurred at the anchor site during surgical procedures, sutures were then damaged by cutting approximately 33% of their width with a razor blade placed in a custom jig. This percentage of suture damage was chosen after a pilot study so that the newer polyethylene suture (FiberWire) could be tested in bioabsorbable anchors without routinely destroying the anchor's eyelet. The goal was to minimize anchor breakage as a confounding factor. The total width of the suture and the cut depth were measured by use of a light microscope attached to an electric micrometer to determine total remaining cross-sectional area.

For all tests, the suture anchors were clamped between the flanges of a vise. The suture was passed through the suture anchor eyelet. The free ends of the suture were wound around a metallic hook to avoid weakening the suture with knot tying. For single-pull, load-to-failure testing, the load was applied to both free ends of the suture parallel to the axis of the anchor insertion, as in the U test[2,3] (Fig 1). For tests involving damaged suture, the damaged area was placed against the superior rim of the anchor loop, facing away from it, toward the center of the eyelet. All tests were performed at a displacement rate of 60 mm/min on an MTS 858 Bionix machine (MTS, Eden Prairie, MN). The anchor was rotated 180° after each test to reduce any error resulting from manufacturing variance. Any damaged anchors were discarded. Any test that resulted in anchor failure was discarded so that only data where suture strength was the limiting factor were analyzed. The load to failure (LTF) was recorded as the maximal load.

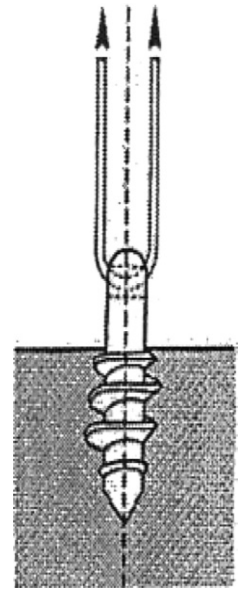

FIGURE 1. Diagram of suture anchor U test. (Reprinted with permission.[3])

Technically, the term *ultimate tensile stress* is only used for tests that solely measure material properties, such as the straight-line pull test, and this term is technically incorrect for a test involving an interaction with another object (i.e., a suture anchor). Therefore, for the tensile failure test, we use the term *failure stress* (FS) to denote the material property of the suture, as well as its interaction with the suture eyelet. FS was calculated as LTF divided by cross-sectional area, which had the decreased area corrected for in damaged sutures. Because the purpose of this study is to evaluate the biomechanical properties of suture and not the anchor, only trials that failed because of suture breakage were included in the analysis.

The friction of damaged and undamaged sutures was measured while being pulled through a suture anchor eyelet at a 45° angle, a different angle than was used for the LTF suture anchor test. An additional 24 sutures of each type were used for the friction test; 12