Pullout Strength of Knotless Suture Anchors

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Purpose: Suture anchors are used consistently for repairs of soft tissues, especially around the glenohumeral joint. These anchors can be used either arthroscopically or in an open procedure to anatomically restore the labrum and capsular tissues to the glenoid after avulsion injuries (Bankart lesion). The purpose of this study was to analyze the pullout strength of a new knotless suture anchor (Mitek Knotless Suture Anchor; Mitek, Norwood, MA) compared with 2 commercially available suture anchors that require knots to be tied (Mitek Panalok 3.5-mm Anchor and Mitek GII Quick Anchor). **Type of Study:** Randomized cadaveric study. **Methods:** Three groups of 10 anchors were tested on 15 fresh-frozen cadaveric glenoids. Two anchors were affixed to the anterior glenoid in subchondral bone, 1 each from 2 groups. In this way, the variance of bone density among groups was minimized. The anchors requiring knots were fixed to the glenoid and tied to a ring using a Duncan knot with 3 half-hitches alternating posts. The Knotless Anchor was looped through the ring and anchored into the glenoid as described by the manufacturer. All constructs were then tested for tensile strength on an Instron machine (Canton, MA) using a crosshead speed of 200 mm/min. Ultimate failure was defined as complete failure of the construct (either suture breakage or anchor pullout). Data were then analyzed for statistical significance using analysis of variance analysis among the 3 groups, and a 2-tailed *t* test for statistical significance among groups. **Results:** The average failure under tensile load for the GII, Panalok, and Knotless Anchors were 471.5 N, 432.8 N, and 650.0 N, respectively. Statistical analysis showed a statistical difference between the Knotless Anchor and the GII and Panalok sutures ($P = .02$). Two-tailed *t* tests between the Knotless Anchor and the GII or Panalok Anchors were also significant ($P = .02$ and $P = .02$, respectively). Observations included a large standard deviation within groups. This is thought to result from the variation in bone density because markedly lower tensile loads were recorded for those anchors that pulled out from the bone before suture failure. **Conclusions:** The Knotless Suture Anchor is a statistically stronger construct with respect to tensile loads. It appears to be a viable option for any type of soft-tissue repair around the glenoid. **Clinical Relevance:** Because the knot in suture repair is consistently the weakest point in the construct and because of the difficulty in tying knots arthroscopically, the Knotless Suture Anchor appears to be a stronger and easier method for both arthroscopic and open Bankart repair, with or without capsular shift. **Key Words:** Suture anchor—Bankart—Arthroscopy.

The use of suture anchors for repair of Bankart lesions in shoulder instability has gained increasing popularity in the last decade. A Bankart repair, with or without capsular shift, is performed in patients with recurrent instability following traumatic dislocation.[1] Techniques for both open[2] and arthroscopic[3] repairs have been described using suture anchors. Advantages of the suture anchor include ease of use, the ability to anatomically reduce the labrum and capsule to the glenoid, and obviating the need to drill tunnels through the glenoid.[4] Disadvantages include the possibility of the anchors becoming loose bodies in the joint and the difficulty of tying knots arthroscopically with subsequent knot failure. When repairing the soft tissues, it is essential that secure knots be tied to obtain successful results. This can be difficult when performing the repair arthroscopically. Usually, these knots consist of an initial slip knot followed by a series of half-hitches. It has previously been shown that

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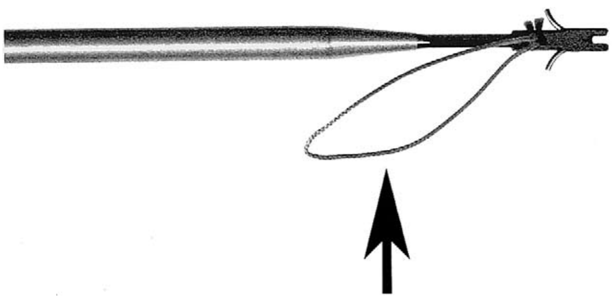

FIGURE 1. Knotless Suture Anchor with suture loop (arrow).

knots tied under simulated arthroscopic conditions have a lower ultimate strength than those tied open.[5] Recently, a new suture anchor has become available for use that does not require knots for fixation of soft tissues (Knotless Suture Anchor; Mitek, Norwood, MA). The anchor is similar to those already in use (GII Quick Anchor, Mitek); however, the suture used is a loop that is passed through the tissues and captured by a channel at the tip of the anchor (Fig 1). Inserting the anchor to the proper depth then tensions the tissue. The purpose of this study was to compare the ultimate tensile strength of this suture with that of 2 Mitek anchors already in widespread use, the GII Quick Anchor and the Panalok Anchor.

METHODS

Three groups of 10 suture anchors each were tested. The 3 groups consisted of the Knotless Suture Anchor, the GII Suture Anchor, and the 3.5-mm Panalok Suture Anchor (Fig 2). The Knotless Anchor is a suture anchor with a loop of No. 1 Ethibond suture (Ethicon, Somerville, NJ) attached to the anchor (Fig 1). The loop is passed through the intended soft tissue, and then captured by a channel at the tip of the anchor. The anchor is then inserted into the bone. Soft-tissue tension is achieved by controlling the depth of insertion. The GII Anchor is a conventional metallic anchor with 2 strands of No. 2 Ethibond attached. The anchor is inserted in the bone, and the soft tissue is repaired with the suture and tied with a knot. The Panalok is similar to the GII, but the anchor is a bioabsorbable toggle.

Fifteen fresh-frozen cadaveric scapulas were thawed and stripped of all soft tissues. The labrum was then detached from the glenoid. The scapulas were then randomly divided into 3 groups of 5. Two suture anchors, each from a different group, were placed in the subchondral bone at the 1- and 5-o'clock positions for right scapulas, and the 11- and 7-o'clock positions for left scapulas. The position of the anchor on the glenoid was also alternated so that 5 were tested in the superior position and 5 were tested in the inferior position. By alternating position and scapula, effects of differing bone density among groups were minimized.

For the GII and Panalok Anchors, a Duncan loop with 3 half-hitches alternating posts was tied around an aluminum ring (Fig 3). This knot configuration has previously been shown to be one of the strongest arthroscopic knots currently in use.[5] All knots were tied by hand by the lead author after extensive practice and testing. The knots were cinched so that the ring came into contact with the glenoid. For the Knotless Anchors, the loop of suture was passed through an aluminum ring, captured by the tip channel, and the anchor was then secured into the glenoid as directed by the manufacturer. Again, the suture was tensioned so that the ring came into contact with the glenoid. Of note, 1 GII Anchor and 1 Panalok Anchor were eliminated from the study because of failure during insertion secondary to operator error.

The scapulas were then tested on an Instron 1122 machine (Instron, Canton, MA). The scapulas were secured by 2 rigid arms, and the ring was pulled at

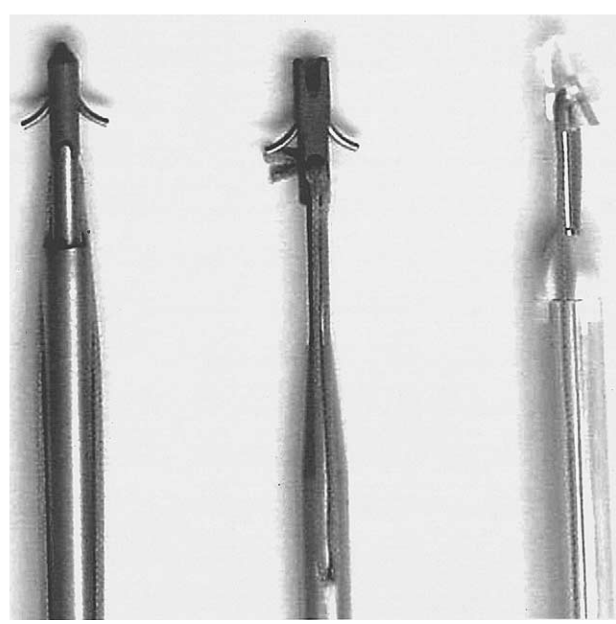

FIGURE 2. Suture anchors tested (from left to right): GII Quick Anchor, Knotless Suture Anchor, and the 3.5-mm Panalok Anchor.

Figure 3. Duncan Loop.

3.3 mm/second in a vector perpendicular to the glenoid (Fig 4). The ultimate force to failure was then recorded. Ultimate failure was defined as suture breakage or displacement of the anchor from the bone.

The results were compared statistically using analysis of variance with $P = .05$ used as the level of significance. The knotless group was also compared with either the GII or the Panalok group separately using a 2-tailed t test, with $P = .05$ as the level of significance.

RESULTS

Average load to failure is illustrated in Fig 5. As can be seen, the Panalok group consistently resulted in lower loads, averaging 434.8 N. The GII group was slightly higher at 471.5 N, and the Knotless Anchor group was highest at 650.0 N. These differences were statistically significant among groups ($P = .02$). The differences were also statistically significant when the Knotless group was compared with either the GII or the Panalok group separately in a 2-tailed t test ($P = .02$ and $P = .02$, respectively).

It was observed that in each group the majority of failures were caused by suture breakage. However, in the Knotless group, 1 anchor pulled out from the glenoid before the suture failed; in the Panalok group, 2 pulled out early; and in the GII group, 3 failed before suture breakage. The pullouts occurred as follows: from the 1-o'clock position for the Knotless; from the 1- and 5-o'clock positions for the Panalok, and 2 from the 5-o'clock and 1 from the 1-o'clock positions for the GII group. Because the sutures were alternated on the glenoid, 1 scapula had both a GII and a Panalok fail in this manner. The remaining 4 pullouts were from different scapulas. In each case, the anchor was pulled from the bone before suture breakage. It is thought that this was due to poor bone quality, although data for patient age of the scapulas was not readily available. All remaining samples failed as a result of suture breakage.

The pullouts resulted in consistently lower loads to

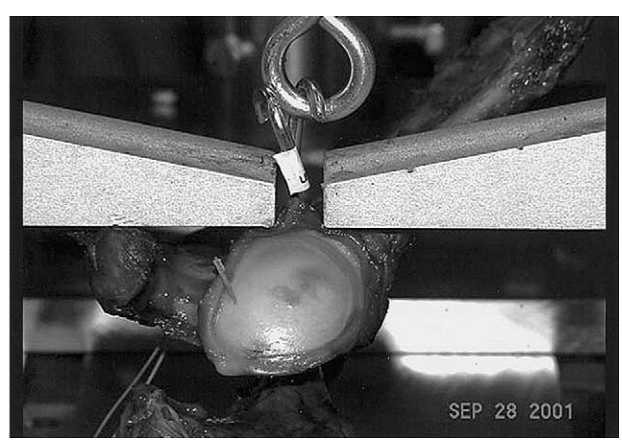

Figure 4. Apparatus for testing load to failure of suture anchors from the glenoid.

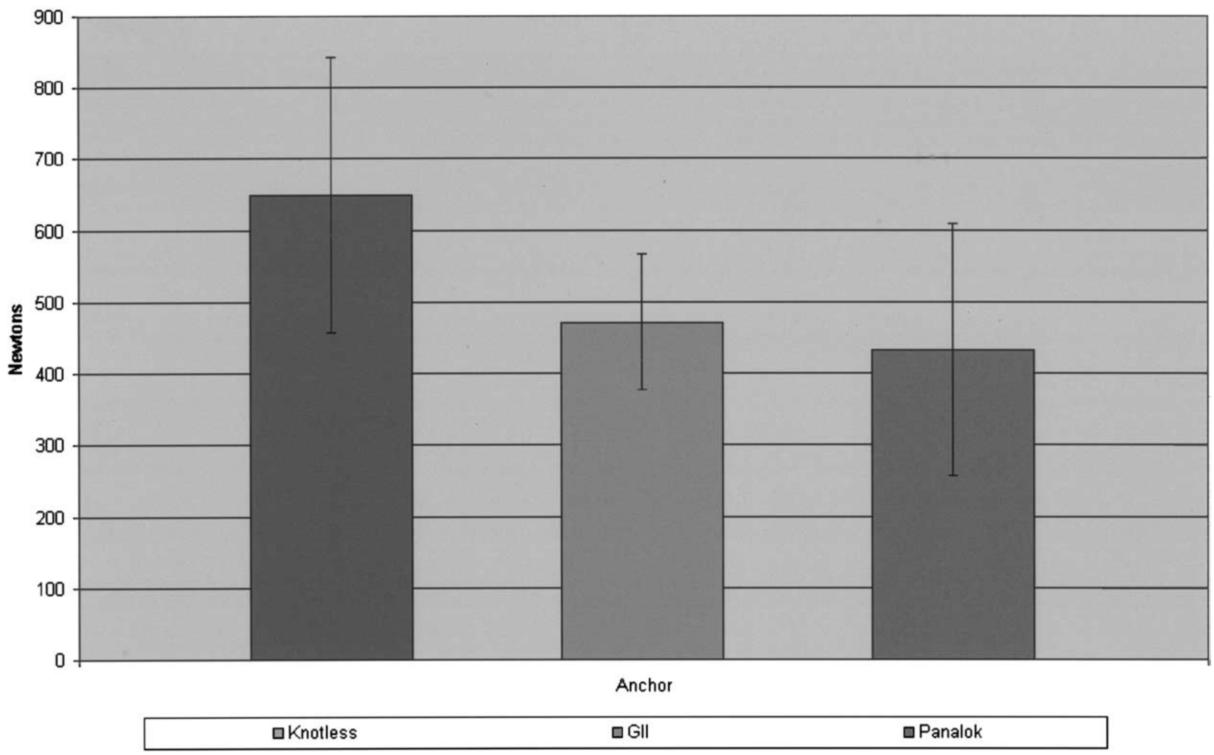

Figure 5. Ultimate load to failure of the tested suture anchors.

failure than those in which the suture failed first: Knotless, 293.8 N versus 695.7 N; Panalok, 173.5 N versus 506.9 N; and GII, 361.0 N versus 526.7 N. If these samples are eliminated from each group, and the groups are again compared using analysis of variance, the difference remains statistically significant ($P = .01$). A 2-tailed t test was also significant if the Knotless Anchors were compared with either the GII or the Panalok anchors ($P = .01$ and $P = .02$, respectively).

DISCUSSION

Since the original description of the Bankart (or Perthes) lesion in recurrent shoulder instability,[1] several methods have been described for repair. The gold standard has been the open repair, as originally described by Rowe et al. in 1978.[2] They reported a 97% success rate at a minimum of 1 year follow-up (mean, 6 years). Complications included degenerative arthritis, joint stiffness, neurovascular injury, infection, and recurrent instability. All subsequent repair techniques are usually compared against these results. Recently, arthroscopic repair for instability has gained popularity. Fixation devices include metallic devices, bioabsorbable tacks, and sutures through tunnels. Arthroscopically placed staples were first described by Detrisac and Johnson in 1993.[6] The instability recurrence rate at an average of 4 years was 11%, but 10% of patients required staple removal. Wiley[7] described a technique of stabilization using a metal rivet. At a mean of 6 months' follow-up, 1 of 10 patients' repairs had failed. A major disadvantage to the technique was the requirement of an additional procedure to remove the rivet in all patients. Because of the complications inherent with metallic devices, bioabsorbable tacks have been used for anterior stabilization. The majority of reports describe using the Suretac (Acufex Microsurgical, Mansfield, MA). This is a cannulated polyglyconate ribbed tack which is affixed to the glenoid. The tack is fully absorbed in 6 weeks, essentially eliminating the need for possible removal. Results of this device have looked promising. Arciero et al.[8] used this device in military cadets who had sustained an initial traumatic anterior dislocation. At 1-year follow-up, 95% were rated as good or excellent results with a 3% subluxation rate. It appears at this time that this device is well suited to the first-time dislocator with an otherwise intact capsular complex.

Additional techniques have been developed to address both the labral lesion and the capsular laxity.

This usually involves repairing the labrum and medializing the capsule to an abraded glenoid using either sutures through transglenoid tunnels or suture anchors fixed to the anterior glenoid. Morgan and Bodenstab[9] first reported on using transosseous tunnels for arthroscopic fixation. Morgan[10] later reported a 5% rate of recurrent instability with this technique, with most failures occurring in athletes.

In an effort to improve fixation and avoid possible complications inherent with transosseous tunnels, much work has focused on suture anchors for the repair of Bankart lesions. Results of this repair have been comparable to those achieved with open repair, with a failure rate for recurrent instability of 11%.[11] Difficulties with tensioning the soft tissues adequately, and with tying the knots arthroscopically, have been offered as possible reasons behind arthroscopic repairs that are not as secure as those tied open.[12]

It is possible that by eliminating the need for tying knots during a Bankart repair, lower recurrence rates could be achieved. Further, because the knot in a repair is consistently the weakest link in the repair, even if tied adequately, eliminating the knot should result in a stronger construct. Our data would suggest that this is the case with the Knotless Suture Anchor. The load to failure for the knotless system was consistently higher than in the conventional systems that required knots. In addition, the loop used for repair results in 2 strands of No. 1 Ethibond across the repair site, instead of a single strand of No. 2 Ethibond. By dispersing the forces across a wider surface area of tissue, the failure rate should be reduced.

During testing of the anchors, it was observed that lower failure values were achieved when the anchor pulled from the bone before the suture failed. While this may result from improper insertion, it is likely that cortical density contributed to the failure in some instances. The ages of the cadaveric specimens were not available during the study, but a wide variation in bone density was observed during insertion of the anchors. It is likely that poor bone quality contributed to the anchor pulling out before suture failure.

Use of the Knotless Suture Anchor results in a stronger construct during repair of soft tissues in the anterior glenoid compared with the GII and Panalok anchors. The absence of a knot and the double-strand configuration of the Knotless Anchor contribute to this finding. The knotless configuration makes insertion during arthroscopy easier and quicker, but its use should also be considered for open repair because of its superior failure loads compared with the other tested anchors.

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