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Knotless Suture-Based Anchors

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Rotator cuff repair, labral repair, and stabilizations are commonly performed procedures in the shoulder. Until the last decade these were usually performed using open or mini-open techniques. Recent advances in surgical techniques allow most of these procedures to be done arthroscopically. Original arthroscopic techniques required the use of suture anchors and arthroscopic knot tying. The newest generation of arthroscopic fixation devices utilizes knotless suture-based anchors which eliminate the need for knot tying. These devices are relatively new to the market and afford the surgeon the ability to achieve a stable repair while bypassing the often time-consuming and frustrating task of tying arthroscopic knots. An understanding of the selection of such devices and their biomechanical parameters is important for those contemplating arthroscopic repairs. In this article we review the knotless suture-based anchors available for use in both labral and rotator cuff arthroscopic surgery.

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Since the arthroscope was introduced as a tool for shoulder surgery, surgeons have gained more insight regarding shoulder pathology. The intra-articular viewing and working access has led to many new diagnoses as well as facilitated new procedures and minimally invasive techniques to address shoulder pathology. The introduction and evolution of suture anchors have facilitated our ability to address pathoanatomy and pathophysiology of the shoulder in a less invasive manner. Early anchors could be broken down into 2 categories: nonsuture based and suture based. The nonsuture-based anchors include bioabsorbable tacks. Suture-based anchors consist of a metallic or bioabsorbable anchor, which is placed into the bone, and free suture ends, which are looped through the anchor. These first-generation anchors with free suture ends require open or arthroscopic knot tying, which has a sharp learning curve and can be tedious even for the experienced surgeon. The recent introduction of knotless suture-based anchors has allowed the surgeon to achieve a stable suture repair of soft tissue to bone while bypassing one of the most time consuming and frustrating steps. Many companies have recently introduced a knotless anchor to the market, each with its own technique for use. Because these anchors have not been available until recently, a paucity of peer-reviewed literature exists regarding their use and clinical outcome. In this review, we will list available knotless anchors and discuss their characteristics.

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Knotless Suture-Based Anchors

Knotless suture-based anchors include the UltraFix Knotless MiniMite Suture Anchor (Linvatec, Largo, FL), the Knotless Suture Anchor (Mitek Products Inc, Westwood, MA), the Magnum Knotless Fixation Implant (Opus Medical Inc, San Juan Capistrano, CA), TwinFix Ti Quick-T Fixation System (Smith & Nephew Endoscopy, Andover, MA), and the Corkscrew Parachute Tissue Anchor (Arthrex Inc, Naples, FL) (Table 1, Fig. 1).

These devices can be broken down into 2 groups based on the technique used: either a suture-first technique or a through-tissue technique. The UltraFix Knotless MiniMite, Knotless, and Magnum use the suture-first technique and achieve a no-profile repair. With this technique, the suture is first passed independently through the tissue and then engaged in the anchor. The anchor and engaged suture are then placed directly into a drill hole in the bone. Tissue tension may be adjusted as the anchor is inserted.[1] An advantage of these knotless anchors is that the metallic or bioabsorbable anchor is placed completely in the bone. Only the suture is maintained in the joint. This may allow these anchors to be less prone to a synovitic reaction or sterile effusion previously described with anchors using intra-articular bioabsorbable components.[2,3]

The Corkscrew Parachute Tissue Anchor and TwinFix Ti Quick-T Fixation System achieve a low-profile repair using the through-tissue technique When using this technique, the anchor is first placed through the tissue and then directly into the underlying bone; an attached suture follows the anchor through the tissue and pulls a solid disc down to hold the secured tissue. The disc remains in the joint, on top of the

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Table 1 Knotless Suture-Based Anchors

UltraFix Knotless MiniMite Suture Anchor (Linvatec, Largo, FL)
Knotless Suture Anchor (Mitek Products Inc, Westwood, MA)
Bioknotless Suture Anchor (Mitek Products Inc, Westwood, MA)
Bioknotless RC Suture Anchor (Mitek Products Inc, Westwood, MA)
Magnum Knotless Fixation Implant (Opus Medical Inc, San Juan Capistrano, CA)
TwinFix Ti Quick-T Fixation System (Smith & Nephew Endoscopy, Andover, MA)
Corkscew Parachute Tissue Anchor (Arthrex Inc, Naples, FL)

secured tissue, providing a large footprint of secured soft tissue.

The Ultrafix Knotless MiniMite Suture Anchor is designed for arthroscopic anterior shoulder instability procedures. It uses a 2.3-mm metallic anchor and a loop of suture that is passed through the tissue. The surgeon uses a Shuttle Relay (Linvatec, Largo, FL) to first pass the suture through the tissue to be secured. The suture is then loaded into the anchor, and the surgeon then places the anchor directly into a drill hole. After placement of the anchor into the drill hole, the surgeon appropriately tensions the tissue and then deploys the anchor.

There are 3 versions of the Knotless Suture Anchor currently available. For shoulder labral and capsular fixation, a 2.9-mm titanium and a 2.9-mm PLA bioabsorbable Bioknotless (Mitek Products Inc) version are available. For repair of rotator cuff tears, the bioabsorbable implant is available in a larger version, the 3.2-mm Bioknotless RC Suture Anchor (Mitek Products Inc).

The Knotless Suture Anchor has a short closed loop of suture secured to the tail end of the anchor. This loop is available in no. 1 Panacryl (Ethicon, Inc, Somerville, NJ) and no. 1 Ethibond (Ethicon, Inc). The short loop is passed through the detached tissue and then captured in a channel at the tip of the anchor before insertion of the anchor into a 2.9-mm drill hole (3.2 mm for the RC anchor) in the bone. The surgeon appropriately tensions the soft tissue as the anchor is tapped down into the drill hole.[4]

The metallic version of this anchor appears similar to a GII Suture Anchor (Mitek Products Inc) anchor and was compared in bone pullout testing to the GII anchor in pig femurs.[4] The knotless anchor with its no. 1 Panacryl suture loop showed significantly higher suture failure loads in pig femurs than a GII anchor loaded with no. 1, no. 2, or no. 5 Ethibond (Table 2). This is partially a function of the closed loop of suture attached to the anchor, effectively producing a double suture in the repair as opposed to the GII and its single-thickness suture. The study also determined in bone pullout testing that there was no significant difference between the metallic Knotless anchor and the GII anchor (knotless 60.96 ± 14.29 lb vs GII 55.63 ± 17.12 lb).[4]

Figure 1 The implants are from left to right: Bioknotless Suture Anchor (Mitek Products Inc, Westwood, MA), Bioknotless RC Suture Anchor (Mitek Products Inc), Knotless Suture Anchor (Mitek Products Inc), UltraFix Knotless MiniMite Suture Anchor (Linvatec, Largo, FL), Corkscrew Parachute Tissue Anchor (Arthrex Inc), Magnum Knotless Fixation Implant (Opus Medical Inc, San Juan Capistrano, CA), and TwinFix Ti Quick-T Fixation System (Smith & Nephew Endoscopy, Andover, MA).

Table 2 Average Suture Failure Loads

	Failure load (lb)
Knotless anchor	55.95 ± 3.95
GII anchor with #1 Ethibond	24.32 ± 1.69
GII anchor with #2 Ethibond	30.01 ± 2.48
GII anchor with #5 Ethibond	51.29 ± 3.14

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The Magnum Knotless Fixation Implant is designed for repair of rotator cuff tears. This stainless steel implant is part of the AutoCuff system (Opus Medical Inc), using a SmartStitch suturing device (Opus Medical Inc), which allows the surgeon to arthroscopically pass an "incline" mattress stitch with a no. 2 braided polyester suture through the cuff tendon. This "incline" mattress configuration consists of 2 limbs of suture spaced 4.5 mm apart from each other as they exit the bursal side of the tendon 11 mm from the lateral edge and loop through the articular side of the cuff 13 mm from the lateral edge. The free ends of this "incline" mattress stitch are then passed through the metallic anchor, the anchor is placed into a drill hole in the bone, and a wheel on the pistol-grip is turned, pulling the edge of the tendon laterally to the drill hole and allowing the surgeon to appropriately tension the repair over a large footprint.

A study comparing the strength and failure mode of several different suture anchors included the Magnum Knotless Fixation Implant and several traditional metallic and bioabsorbable anchors with free ends of suture requiring knot tying (Table 3). In this particular study, the Magnum showed superior loads to failure in the metaphyseal and diaphyseal cortices of fresh porcine femurs. When a cancellous trough was used, the Magnum was second to the TwinFix Ti 5.0 (Smith & Nephew Endoscopy) and superior to other anchors in load-to-failure testing.[5]

The Corkscrew Parachute Tissue Anchor uses a titanium anchor and an 8-mm diameter, 1.5-mm thick PLLA, disc which is held securely on the tissue by no. 4 nonabsorbable suture after the anchor has been placed through the tissue. The disc remains in the subacromial space.

The TwinFix Ti Quick-T Fixation System utilizes a titanium TwinFix Ti soft-tissue anchor (3.5 mm and 5.0 mm available) and is combined with a 10-mm wide "T" bar made of a nonabsorbable polymer and a pretied knot on a no. 2 Durabraid suture (Smith & Nephew Endoscopy). After the anchor has been placed, the pretied knot is tightened appropriately, and the "T" bar, which remains intraarticular, is appropriately tensioned and held firmly against the repaired tissue.

Authors' Preferred Method

When using a knotless anchor for labral and capsular repair/shift, we prefer to use the Mitek Knotless anchor because it allows the surgeon to efficiently provide a stable repair without the need for arthroscopic knot tying and without leaving metallic material in the joint. The authors use the Opus Magnum for arthroscopic and miniopen rotator cuff repairs because it facilitates an efficient, rigid no-profile repair of the cuff over a broad surface area.

Conclusion

Soft-tissue attachment to bone has been significantly advanced by the introduction of anchors, both suture-based and nonsuture anchors. Historically, suture-based anchors have required the surgeon to tie knots. Arthroscopic knot tying is a technically demanding procedure, and many surgeons are unwilling to perform an all-arthroscopic technique because of the technically demanding nature of arthroscopic knot tying. For this reason, many of these repairs have been performed in an open or miniopen procedure rather than arthroscopically. Anchors that allow secure fixation of soft tissue to bone and do not require knot tying have facilitated a trend toward arthroscopic repair of labral and cuff pathology. Bioabsorbable tack-like devices have been shown to provide adequate fixation to bone, but concerns over the biodegradable material in the joint, dislodgement, breakage, and loss of fixation with resorption of the implant have inhibited their use by many surgeons.[2,3] As with any new device, these new suture-based knotless anchors require familiarity with their use. Once a comfort with use of these new devices is achieved, they provide the best of many worlds. They have been shown to provide secure suture fixation of soft tissue to bone, they do not require knot tying, and they provide a no-profile or low-profile repair without

Table 3 Average Load to Failure Based on Bone Type

	Diaphyseal Cortex (N)	Metaphyseal Cortex (N)	Cancellous Trough (N)
Magnum (Opus Medical, San Juan Capistrano, CA)	736	509	510
TwinFix Ti 5.0 (Smith & Nephew Endoscopy, Andover, MA)		448	616
TwinFix Ti 3.5 (Smith & Nephew Endoscopy, Andover, MA)	539	442	422
SuperRevo (Linvatec, Largo, FL)	437	468	448
Duet (Linvatec, Largo, FL)	387	336	357
TwinFix AB (Smith & Nephew Endoscopy, Andover, MA)	261	485	456
UltraSorb (Linvatec, Largo, FL)	251	174	139
RotorloC (Smith & Nephew Endoscopy, Andover, MA)	247		
AlloAnchor RC (Regeneration Technologies, Alachua, FL)		268	286
BioCorkscrew 5.0 (Arthrex Inc, Naples, FL)		222	224
BioCorkscrew 6.5 (Arthrex Inc, Naples, FL)		181	218

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requiring a nonsuture component of the anchor to remain intraarticular.

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