The Arthroscopic Square Knot: Fiction or Fact?

Steven M. Hammerman, MD, Hussein Elkousy, MD, T. Bradley Edwards, MD, Daniel P. O'Connor, PhD, and Gary M. Gartsman, MD

Abstract

The square knot is the gold standard for open surgical knot tying. One criticism of arthroscopic shoulder surgery is that arthroscopic knots are not as secure as square knots tied during traditional open surgery.

In this brief technical note, we describe a simple technique for tying arthroscopic square knots that the senior members of our group have been using in clinical practice for several years with successful results.

The square knot is the gold standard for open surgical knot tying. One criticism of arthroscopic shoulder surgery is that arthroscopic knots are not as secure as square knots tied during traditional open surgery.[1] A square knot tying technique that has been called the "most difficult to tie arthroscopically" involves the inefficient maneuver of removing the knot-tying instrument from one suture limb and applying it to the other suture limb for each throw.[2] Others have stated that asymmetric tension in the suture limbs prevents formation of a square knot.[1]

In this brief technical note, we describe a simple technique for tying arthroscopic square knots that the senior members of our group have been using in clinical practice for several years with successful results.

Technique

The first important concept in tying arthroscopic square knots is that of *post* and *nonpost* limbs. In simple knots with 2 suture limbs, the straight limb is under more tension and functions as the post limb; the other limb wraps about the post limb and functions as the nonpost limb (Figures 1A, 1C). When a half-hitch is thrown, these laid-down limbs reside in 1 of 3 relationships. In the first 2 relationships, they are laid down with unequal tension, creating half-hitches; one limb is wrapped around the other[3] (Figures 1A, 1C). In the third relationship, there is no wrapping of one limb around the other, and the result is a flat throw or an "overhand knot" without a post.[4] This configuration is created when the throw is being laid down with equal tension applied to the limbs in opposite directions (Figure 1B). Here the post limb is not defined by which limb passes through the knot pusher (captured limb). As in open knot tying, application of differential tension allows the hitch to be "spilled" or "flipped." The post limb may be switched at any point during suture passing simply by altering the tension on each limb, either by pulling on the free limb or using the knot pusher to pass-point and pull tension on the captured limb[5] (Figure 1).

"...we describe a simple technique for tying arthroscopic square knots..."

In tying arthroscopic square knots, one-handed half-hitches are sequentially thrown in alternating directions external to the working cannula. For each and every throw, the free suture limb is passed around the captured limb; by definition, the captured limb initially appears as the post. Still external to the cannula, the post is switched by applying differential tension to the limbs; the captured limb is relaxed while the free limb

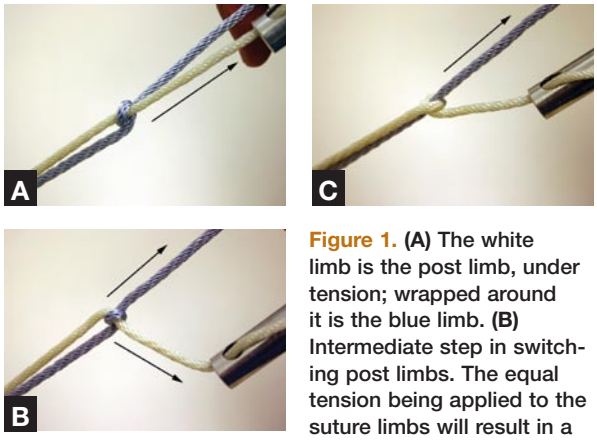

Figure 1. (A) The white limb is the post limb, under tension; wrapped around it is the blue limb. **(B)** Intermediate step in switching post limbs. The equal tension being applied to the suture limbs will result in a flat throw. **(C)** The blue limb is under more tension and has become the post limb.

Dr. Hammerman is Assistant Surgeon, Dr. Elkousy is Staff Surgeon, Dr. Edwards is Staff Surgeon, Dr. O'Connor is Research Director, and Dr. Gartsman is Staff Surgeon, Texas Orthopedic Hospital, Houston, Texas, and Fondren Orthopedic Group, Houston, Texas.

Address correspondence to: Hussein Elkousy, MD, Fondren Orthopedic Group, LLP, 7401 S Main St, Houston, TX 77030-4509 (tel, 713-799-2300; fax, 713-794-3380; e-mail, he700@fondren.com).

Am J Orthop. 2009;38(1):14-16.

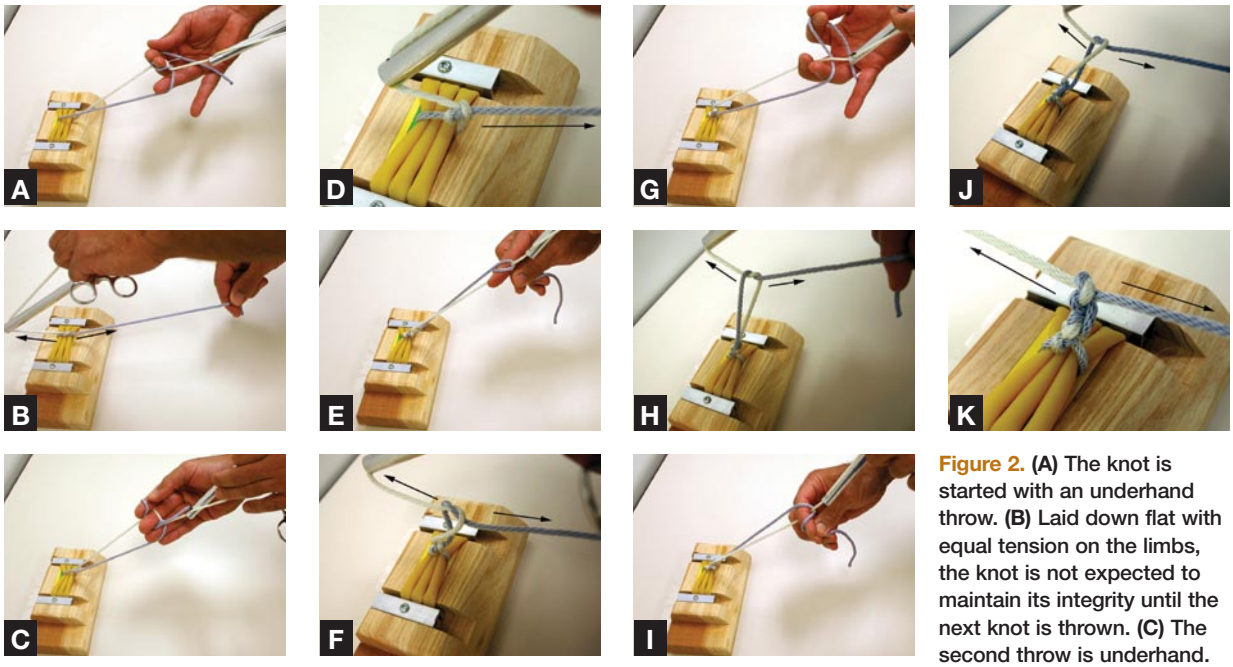

Figure 2. **(A)** The knot is started with an underhand throw. **(B)** Laid down flat with equal tension on the limbs, the knot is not expected to maintain its integrity until the next knot is thrown. **(C)** The second throw is underhand. **(D)** Tension is applied to the blue (post) limb, and the knot is slid down to the target tissue though not locked. The knot is held in place until more knots are added. **(E)** The third throw is overhand. **(F)** As the knot approaches the target tissue, tension on the free limb is relaxed, and tension on the knot pusher is increased to equalize the tension in the limbs. The knot becomes a square laid down with equal tension on the limbs. **(G)** The fourth throw is underhand. **(H)** As the knot approaches the target tissue, tension on the free limb is relaxed, and tension on the knot pusher is increased to equalize the tension on the limbs. The knot becomes a square laid down with equal tension on the limbs. **(I)** The fifth throw is overhand. **(J)** As the knot approaches the target tissue, tension on the free limb is relaxed, and tension on the knot pusher is increased to equalize the tension on the limbs. The knot becomes a square laid down with equal tension on the limbs. **(K)** The final knot is tightened.

is pulled taut and becomes the post. Configuring each throw with the free limb as the post allows the knot pusher to gently pull or draw down the throw through the cannula to the repair site under minimal to no tension. For the throw to be laid flat, the next maneuver is critical. As the throw approaches the target tissue, tension is relaxed from the post (free) limb, and the knot pusher is used to pass-point the captured limb (Figures 2F, H, J). Differential tension is applied to the limbs (more tension on the captured limb than on the free limb). As the tension on the limbs equalizes, the half-hitch starts to invert. At the precise moment the throw begins to flip, equal tension is applied to the limbs, and a flat throw is laid down. This step is repeated with throws in alternating directions.

When we tie an arthroscopic square knot, we begin by using a loop suture grasper to identify the suture limbs and ensure they are not tangled. We usually place the knot pusher on the limb closest to the working cannula so that we can then create a line of pull for the captured limb that closely approximates the axis of the working cannula, thereby allowing the knot pusher to assume a linear piston motion. This setup helps minimize suture manipulation and friction, which can contribute to suture material fatigue and failure. When tying square knots, we usually lay 5 throws: The first 2 hold the knot in place, and 3 flat throws provide backup.

> "When tying square knots, we usually lay 5 throws: The first 2 hold the knot in place, and 3 flat throws provide backup."

The first half-hitch is thrown external to the working cannula, the post is switched to the free limb, and the throw is floated down to the repair site under no tension (Figure 2A). Tension is not applied with the knot pusher until the first throw lies flat (Figure 2B). The second throw is made in the same direction, identical to the first, and floated down (Figure 2C). At this point, the 2 throws are in half-hitch configuration. Only after the knot has been fully drawn down is the knot pusher used to pass-point and tighten the half-hitches. It is critical that the same post is maintained while throwing these first 2 knots. If any differential tension is placed on the post and free limbs, the knot will lock prematurely, before apposing the target tissue. Although the 2 half-hitches are not locked, they

Figure 3. The final knot consists of 2 full square knots (4 flat throws).

provide enough friction to keep the evolving knot and hence the repair in place until subsequent locking throws can be made (Figure 2D). The third throw is made in the opposite direction and is floated down to the cinched knot (Figure 2E). Before the throw is seated, however, tension is relaxed on the post (free) limb, the knot pusher is used to pass-point, and tension is applied to the captured suture (Figure 2F). At the precise moment the throw begins to flip, equal tension is applied to both suture limbs. With the line of pull at almost 180º, the throw lies flat. The fourth and fifth throws are sequentially made in alternating directions and are laid flat in similar fashion (Figures 2G-2K). Suture tails are then trimmed to 3 mm. On completion, the 5-throw knot has the configuration of 2 identical half-hitches about a common post and 3 flat throws creating 2 square knots on top (Figures 3, 4).

Discussion

Much attention has been focused on arthroscopic knots and their purported inability to do what open square knots do. Many different knots have been developed in an attempt to reproduce the open square knot function. Although a technique for tying arthroscopic square knots has been described before, its use in clinical practice has not, presumably because of its reported difficulty. In this article, we have presented a simple, reproducible method for tying arthroscopic square knots. Studies have been done to evaluate the biomechanical function of the arthroscopic square knot.[6]

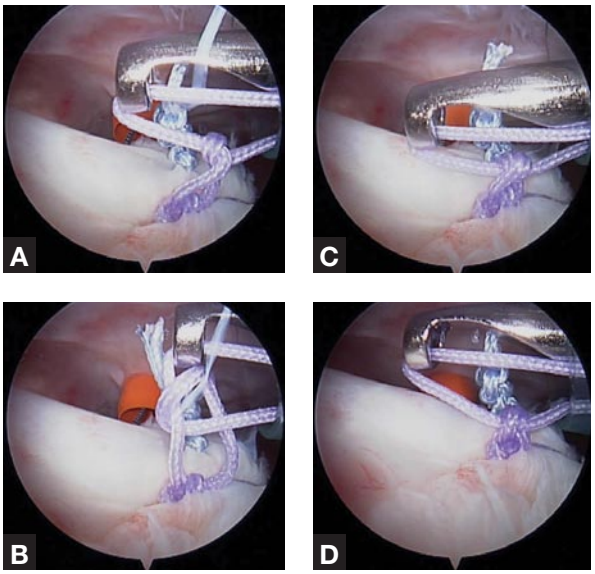

Figure 4. Time sequence of tying arthroscopic square knot in vivo. **(A)** The knot pusher is the post strand. **(B)** The tension is being equalized on both strands to transition to no post. **(C)** Equal tension for a square throw. **(D)** Final square knot.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Ilahi OA, Younas SA, Alexander J, Noble PC. Cyclic testing of arthroscopic knot security. *Arthroscopy*. 2004;20(1):62-68.
2. Nottage WM, Lieurance RK. Arthroscopic knot tying techniques. *Arthroscopy*. 1999;15(5):515-521.
3. Loutzenheiser TD, Harryman DT 2nd, Yung SW, France MP, Sidles JA. Optimizing arthroscopic knots. *Arthroscopy*. 1995;11(2):199-206.
4. Pawson D. *The Handbook of Knots*. New York, NY: DK Publishing; 1998.
5. Chan KC, Burkhart SS. How to switch posts without rethreading when tying half-hitches. *Arthroscopy*. 1999;15(4):444-450.
6. Elkousy H, Hammerman SM, Edwards TB, et al. The arthroscopic square knot: a biomechanical comparison with open and arthroscopic knots. *Arthroscopy*. 2006;22(7):736-741.