Arthroscopic Repair of Peripheral Triangular Fibrocartilage Complex Tears With Suture Welding: A Technical Report

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This report presents a method of arthroscopic repair of the peripheral triangular fibrocartilage complex tears that replaces traditional suture knots with ultrasonic welding of sutures. This will help eliminate potential causes of ulnar-sided wrist discomfort during the postoperative period. (J Hand Surg 2006;31A:1303–1307. Copyright © 2006 by the American Society for Surgery of the Hand.)

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Arthroscopic repair of peripheral triangular fibrocartilage complex (TFCC) tears is now a commonly accepted method. It provides excellent functional outcome, aided in part by the vascularity of the peripheral TFCC. Currently described repairs of the TFCC require subcutaneous suture knots to be used on the ulnar aspect of the wrist to secure the repair.[1–15]

Traditionally the apposition of tissue and the strength of the resulting repair relied on the tying of suture, which has been reported as a potential "weak link" and a point of early failure by suture breakage at the knot.[16–21]

In our experience, the existence of this suture material has been a common cause of complaints among our patients in the postoperative period. Arthroscopic knots are difficult to master, they are time consuming, and most importantly, they are very bulky, which may lead to excessive foreign-body tissue reaction and knot impingement and ultimately may compromise the repair. Knots tied through the mini open incision are not as difficult technically but may lead to similar problems of bulkiness.[16,17] A technology, suture welding, has been introduced that uses ultrasonic energy to weld monofilament suture together in a low-profile loop (Axya Weld; Axya Medical Inc., Beverly, MA), which eliminates the need for knot tying. This is accomplished with a fixation system (Axya Fixation System, Axya Medical Inc.) that uses ultrasonic energy in a small probe-like instrument to compress the 2 limbs of the suture and weld them together. The bonding between the 2 ends of the sutures is produced by a 70-kHz ultrasonic vibration that bonds polymers by localized heating with no thermal damage to the surrounding tissues, because the energy used to perform the welding is contained within the confines of the welding sleeve. The tensile properties of the welded monofilament suture loops are superior to those of knotted monofilament suture.[18] This report presents a method of arthroscopic repair for peripheral TFCC tears of Palmer type IB[22] that avoids the use of suture knots, thus potentially eliminating any discomfort on the ulnar side of the wrist in the postoperative period.

Technique

A regional block anesthesia at the elbow level is administered with the patient in the supine position after the administration of light intravenous sedation. An upper-arm tourniquet is applied, and the shoulder holder is positioned. Once the arm is sterilely prepared and draped, 2 finger traps are applied to the index and middle fingers, and 4.54 kg of traction is applied while the arm is held down with wide tape for countertraction at the tourniquet level.

A 2.7-mm 30° arthroscope is introduced into the 3-4 portal. A cursory examination is performed to inspect the entire radiocarpal joint and confirm the presence of a peripheral TFCC tear.

A 6R or 4-5 portal is created to permit the insertion of a full-radius 2.9-mm shaver. A small joint probe is then substituted for the shaver and is used to assess the integrity of the TFCC.

A 0.5-cm longitudinal incision is made directly over the area of TFCC detachment as determined by external palpation and arthroscopic visualization. Through this incision we pass a needle and insert a small joint grasper to retrieve the suture. It is important to extend longitudinally and ensure that the dorsal sensory branch of the ulnar nerve is not placed in jeopardy.

The TFCC perforation and suture passing can be performed with commercially available instruments or a simple 18-gauge needle. The needle is passed within the longitudinal incision, into the tear and then across the edge of the visualized TFCC detachment in a proximal-to-distal direction. The more volar edge is first perforated, and a 2-0 nylon suture is passed through this needle and retrieved more distally above the disk with a small joint grabber or small straight clamp. When grabbing the suture intra-articularly, it is important to pull out the 18-gauge needle before retrieving the suture to avoid cutting it on the bevel of the passing needle. Once a simple suture is passed, traction is applied and the second needle is more easily passed through the now-taut TFCC disk. This second suture is passed more dorsally and is usually all that is required to close the defect. Both of these stitches usually pass just volar to the sixth compartment, and additional sutures, if required, should be passed across the floor of the compartment by opening the sheath and retracting the extensor carpi ulnaris tendon volarly.

At this point, 2 simple 2-0 nylon sutures are spanning the tear, and traction should be applied to them while the wrist is held in nearly full supination (Fig. 1). This is because the ulnar head will sit more ventrally within the sigmoid notch in supination and allow for a tighter repair of the detached TFCC disk. This also allows for the wrist to be in an advantageous position during the healing process, because it can be difficult to regain supination during the rehabilitation period and shoulder abduction can be used to compensate for limited pronation.

Figure 1. View after TFCC perforation and suture passing.

With arthroscopic visualization and the wrist in supination, the sutures are now prepared for welding (Fig. 2). The welding system (Axya Suture Welding System, Axya Medical Inc.) has 3 components: an ultrasonic generator, a resterilizable handpiece, and a per-patient disposable fixation sleeve. The disposable fixation sleeve with the crossed sutures is placed as close as possible to the TFCC tear while tension is maintained and the slot for the sutures is faced inferiorly toward the tissue. The slot for the sutures or the welding instrument tip is at the tip of the disposable fixation sleeve, and its function is to allow the pass of the crossed sutures to place the tip of the fixation sleeve as close as possible over the repair and to transfer the ultrasonic vibrations to the sutures. It is important to keep the resterilizable handpiece at an angle below the plane of the fixation sleeve so that the device can be easily disengaged from the suture once welded. Once the appropriate tension is applied, which means that the defect is closed and the trampoline effect is restored, the locking button or slide switch at the top of the resterilizable handpiece is moved forward to secure the suture at the desired tension, and the soft silicone or weld button underneath the switch is pressed to weld the suture at the tip of the disposable fixation sleeve (Fig. 3). A green light on the ultrasonic generator will confirm that welding has occurred, and the welded suture loop can then be released by gently retracting the slide switch, pressing down on the repair, and sliding the disposable fixation sleeve distally off the repair site. The disposable fixation sleeve encompasses the now-welded suture in a J-shaped slot. Once the weld occurs, one must slide the sleeve off the suture loop while not disturbing the loop or causing stress to the repair. This is performed by axially directing the sleeve off the welded loop and gently lifting up to disengage the suture from the welding inset area. A hook probe can be used to assess the integrity of the suture weld and also to confirm the restoration of TFCC disk tautness. A second suture is now usually welded at this point in a similar fashion. (Video technique can be viewed online at the *Journal's* Web site, www.jhandsurg.org). The potential complications would be failure of suture welding or loss of tension

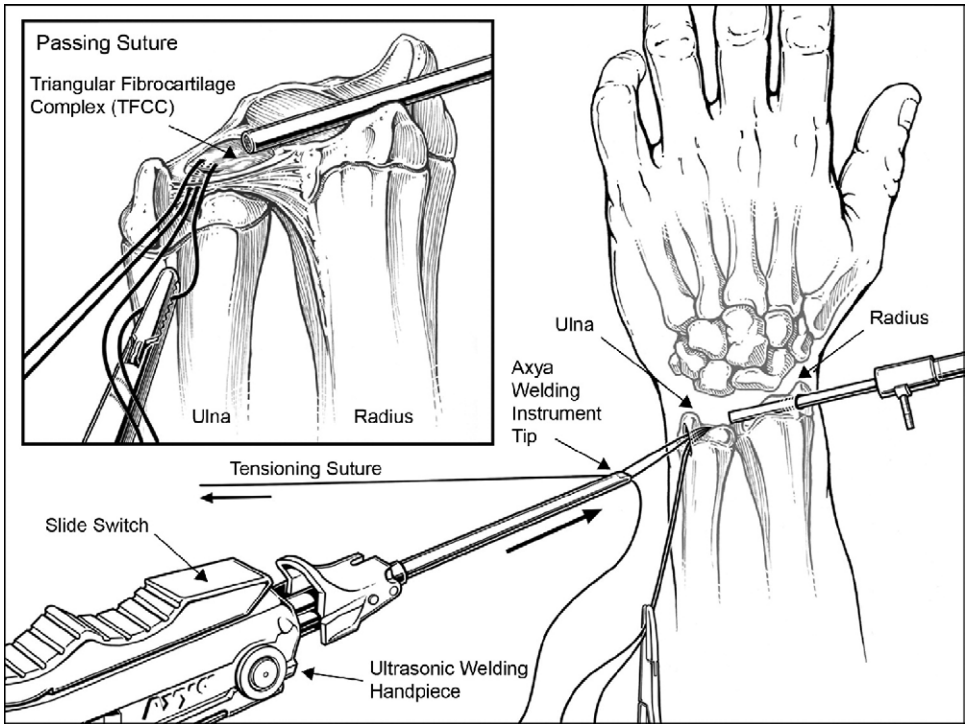

Figure 2. The sutures are prepared for welding.

before the suture is welded, leading to incomplete closure of the tear before welding. The wrist is held in supination while the small incision is closed with a single absorbable skin suture, and the arthroscopy portals are closed with adhesive skin strips.

A sugar tong–type plaster splint is then applied over generous cast padding while the wrist is held in supination and elbow at 90° of flexion. The patient is brought to a recovery room and immediate digital flexion/extension is encouraged.

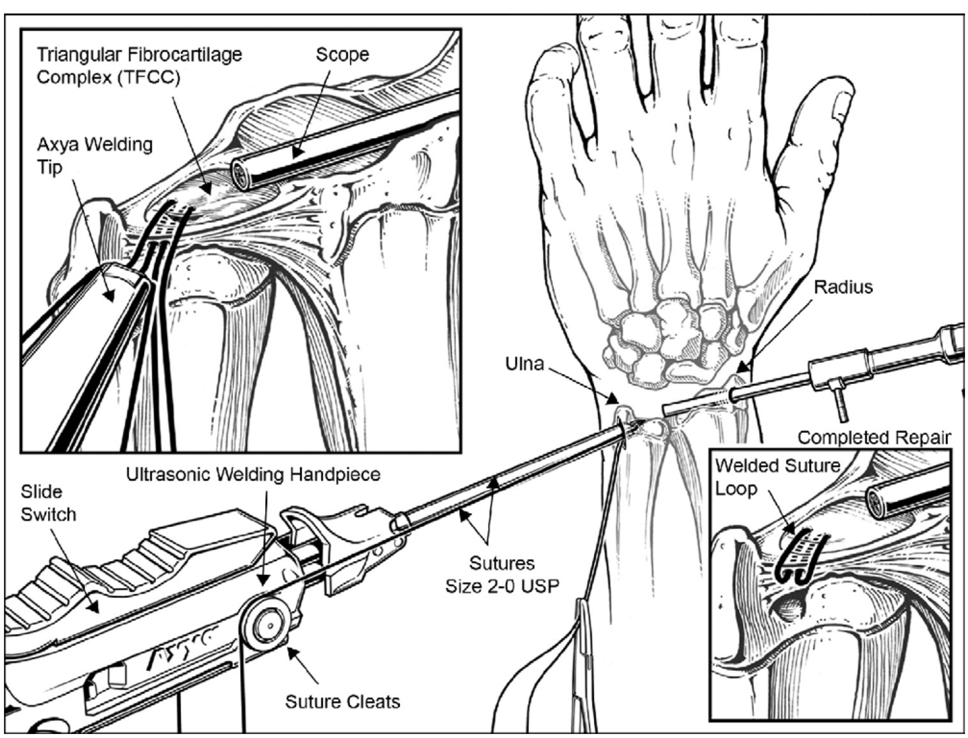

Figure 3. The ultrasonic handpiece is used to weld the sutures.

One week after surgery, the splint is converted to a muenster-type fiberglass cast in supination so that some elbow flexion/extension is allowed but pronation/supination is restricted. Cast removal 5 weeks later should be followed by a 1- to 2-month period of therapy with active range of motion and strengthening.

Discussion

The term *triangular fibrocartilage complex* was first introduced by Palmer and Werner[23] in 1981 to describe the ligamentous and cartilaginous structures suspending the distal radius and ulnar carpus from the distal ulna. It acts as a stabilizer of the distal radioulnar joint and also as a focal point for force transmission over the ulnar side of the wrist.[24] It allows for 6 degrees of motion at the wrist: flexion, extension, pronation, supination, radial deviation, and ulnar deviation.[25] The TFCC is at risk in acute traumatic wrist injuries, especially in high-demand athletes such as tennis players or gymnasts.[26] This injury may actually be one of the most common causes of the so-called *sprained wrist*. The mechanisms of injury include a fall on the pronated and hyperextended wrist, distraction forces applied to the volar forearm or wrist, and distal radial fractures.[27]

Repair of peripheral tears of the TFCC has been suggested to reconstitute important functions related to wrist stability and load bearing.[12] Very few indications still remain for open repair.[3] The inside-out technique was the first arthroscopic method described to fix type IB tears.[10,28,29] The outside-in technique includes perforating the ulnar wrist capsule through the border of the torn TFCC.[8,29] Both of these techniques entail either the advancement or retrieval of 2-0 polydioxanone suture (PDS) sutures to be brought out to the ulnar side of the wrist. The result is that a tied knot, performed through a small incision, sits on the ulnar aspect of the wrist capsule. The superficial knot causes an area of discrete focal tenderness in our experience, despite excellent relief of deep wrist pain.

Suture welding has been used in several surgical fields with success. Ruel et al[30] reported an animal study in which an ultrasonic suture welder intended for intracardiac use was used to adjust suture tension and blend strands together without knots. Echocardiographic evaluation before and throughout left ventricular pressurization showed normal seating and activity of the prosthetic valve in all cases. The *post mortem* inspection confirmed that all the valves were effectively implanted and that welded suture threads were complete and accurately point-fused together.

Richmond[31] compared the mechanical properties of ultrasonically welded sutures and conventional tied knots. He found that the load required to arrive at the point of likely biologic failure (defined as 3 mm elongation) in a repair was considerably larger for welded sutures than for knots. The final elongation at failure was significantly less for welded suture than knotted suture. He then concluded that the welding technique is a better option to repair soft tissues compared with knot tying.[31]

In a preliminary review of our results, during a 1-year period in 2001, the senior author (A.B.) used this technique in 23 patients (9 women, 14 men; mean age, 35 y; range, 18–52 y) in whom a type IB TFCC tear was diagnosed arthroscopically. They were followed up on an average for 17 months. The average wrist arc of motion at final the follow-up evaluation was as follows: extension, 65°; flexion, 56°; supination, 80°; pronation, 85°; radial deviation, 12°; and ulnar deviation, 25°. Grip strength measured with a dynamometer (Jamar; Sammons Preston, Inc., Bolingbrook, IL) in the second position averaged 81% of the contralateral side at final evaluation (range, 53%–105%).

Only 1 patient of 23 complained of pain over the scar at the incision site. We believe, however, that this pain was direct scar tenderness rather than pain from the underlying suture, because it was not palpable.

Suture welding simplifies the arthroscopic repair of TFCC tears and has proven to be at least as mechanically efficient as or even better than tying knots. Welding technology may improve arthroscopic TFCC repair by eliminating the need to tie arthroscopic or open knots, and this avoids tenderness at the incision site. Because the strength of the traditional knot applied is operator dependent, suture welding has the potential to obviate variation in the knot strength and thereby allow for more predictable and reproducible results. This technical report represents a clinical application of ultrasound suture welding technique in the musculoskeletal system. Our experience with its use in TFCC repair may represent a broader application for the future of orthopedic surgery, particularly as arthroscopic techniques advance.

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