Arthroscopic Bone Tunnel Augmentation for Rotator Cuff Repair

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Abstract: Transosseous repair of the rotator cuff has been shown to recreate the anatomic rotator cuff footprint in a secure and cost-efficient manner. However, the potential for sutures cutting through bone remains a concern with this strategy. Devices have been used successfully during open transosseous rotator cuff repair to augment the bone tunnels, potentially avoiding suture cut-out through the weak bone of the greater tuberosity. Recently, arthroscopic transosseous fixation of rotator cuff tears has become an alternative to arthroscopic suture anchor and open transosseous techniques. This method is expected to have the same potential pitfalls at the bone–suture interface as the open technique. The authors describe a technique for rotator cuff repair using a secure method of arthroscopic bone tunnel augmentation.

Transosseous repair of the rotator cuff has been used since the earliest days of cuff repair. Although the ideal method for rotator cuff repair remains an active area of debate, transosseous repair has shown success in clinical reports, remaining the clinical gold standard for treatment. Transosseous repair also compares favorably with respect to the biomechanical parameters of footprint reconstruction, static load to failure, cyclic load to failure, and motion at the repair site. Although conflicting data exist advocating the advantages of suture anchors, the cost of transosseous repair can be far lower, and these cost differences increase with the size of the repair.

Transosseous rotator cuff repair can be prone to failure at the bone–suture interface. This failure can be especially problematic in osteoporotic bone, which has been shown to correlate with an increase in patient age, tear size, and chronicity of the tear. An all-too-common clinical combination. In addition, with transosseous repair, suture cutout through the softer, metaphyseal, lateral tuberosity bone can occur, especially when using certain high-tensile strength sutures.

For transosseous repair, strategies that attempt to combat these problems have included fixation through the location of the strongest bone, a wide bone bridge.
and broad suture tapes to avoid bone cutout. In addition, devices to augment the at-risk lateral suture–bone interface have been developed. The Cuff Link (DePuy-Mitek, Raynham, Massachusetts) is a cannulated, plastic, nonabsorbable polymer grommet that is inserted into the opening of the lateral bone tunnel and covers the edge of the tunnel where the suture makes an acute angle turn around the greater tuberosity bone (Figure 1). This is an attempt to provide a smooth gliding surface to reduce friction during any micromotion that can lead to suture cutout and to provide a reinforcement of the bone at this weak link in the construct.

Clinically, open transosseous rotator cuff repair has shown good long-term results and is recognized as the gold standard technique. A large prospective trial compared open rotator cuff repair with bone tunnel augmentation to arthroscopic treatment with tack devices. However, to the authors’ knowledge, no study has compared rotator cuff repair with and without bone tunnel augmentation.

Arthroscopic transosseous rotator cuff repair has been proposed recently via various...
methods. This technique attempts to harness some of the benefits of transosseous fixation previously discussed but is performed with a minimally invasive arthroscopic technique. Although variations have been described, the authors use the ArthroTunneler arthroscopic transosseous tunneling device (Tornier Inc, Edina, Minnesota) to drill tunnels and pass transosseous sutures in a minimally invasive and reproducible fashion.

The authors have used the Cuff Link device for arthroscopic bone tunnel augmentation in multiple cases with the aim of decreasing suture cutout and potential failure at the bone–suture interface.

**MATERIALS AND METHODS**

Because the bone is a known weak link with transosseous fixation, the authors are reluctant to use this technique in patients with risk factors for poor bone quality (ie, advanced age, osteoporosis, female sex, smoking, diabetes mellitus, chronic tears, and tuberosity cysts seen on preoperative imaging). Middle-aged, healthy, men with acute or acute-on-chronic tears are ideal patients.

**SURGICAL TECHNIQUE**

The patient is placed in the beach-chair position, and a diagnostic intra-articular arthroscopy is completed with standard anterior and posterior portals. The arthroscope is placed into the subacromial space, and a lateral portal is created to facilitate a subacromial decompression and assessment of cuff mobilization. Although important with all rotator cuff repairs, it is especially important to perform a thorough bursectomy with arthroscopic transosseous techniques, including the lateral subdeltoide space, to improve visualization.

A posterolateral viewing portal is established, and any further releases or bursectomies are performed as needed. Via an accessory portal just off the lateral acromial edge, a 2.9-mm medial tunnel is drilled to accommodate the tip of the ArthroTunneler device (Figure 2; Video 1). For tears involving >1 tendon, the authors frequently use 3 tunnels spaced approximately 1 cm apart.

The arm is abducted and the tip of the ArthroTunneler is inserted percutaneously and hooked into the medial drill hole through the lateral portal. A nitinol loop contained within the tip of the ArthroTunneler device is deployed into the medial tunnel, which will be used later to capture and retrieve suture. A 2.5-mm drill is inserted through the end of the device and used to create a lateral tunnel that intersects the medial tunnel through the center of the nitinol loop at a 70° angle. The drill bit is removed from the center of the nitinol loop and device and is then immediately replaced by a preloaded suture inserter, which places the suture into the cancellous bone.

The suture inserter is then removed (leaving the suture in place), and the nitinol loop is retrieved from the center of the nitinol loop and device and is then immediately replaced by a preloaded suture inserter, which places the suture into the cancellous bone.

The suture inserter is then removed (leaving the suture in place), and the nitinol loop is retrieved to securely capture a loop of suture at the tip of the device. The ArthroTunneler device is removed from the repair site, and the loop of the suture is released from the tip (Figure 2; Video 2). The loop is used to shuttle 3 different-colored, heavy braided sutures through the tunnel (Video 3).
Colored hemostats are also helpful to keep the sutures in order.

It is important to realize that the intersecting tunnels have a fixed width from medial to lateral. Therefore, although the best bone is located adjacent to the articular surface, the holes must be lateralized slightly for patients with a wide greater tuberosity.

The medial limb of the sutures are passed through the rotator cuff tendon sequentially using a cannulated 45° lasso (Arthrex Inc, Naples, Florida) (Figure 3). The authors have experimented with various repair constructs and often use 3 tunnels with 2 horizontal mattress and multiple simple sutures (Figure 4). After the sutures are passed through the cuff, 2 box stitches are created using one of the middle transosseous sutures as a shuttle to bring a limb from the anterior and posterior tunnels back through the cuff and the middle tunnel.

If, at any point during the drilling of the tunnels, the authors perceive that there may be any question about the bone’s quality, arthroscopic bone tunnel augmentation is used. The suture limbs (up to 3) from the lateral aspect of the bone tunnel are threaded through the Cuff Link to be reinforced (Figure 5; Video 4). The Cuff Link device is 2.8 × 6.4 mm, and the drill hole created by the ArthroTunneler for the lateral tunnel is 2.5 mm. As such, it has been the authors’ experience that no additional bone preparation has been necessary to achieve a desirable press fit for the augmentation device. The inserter for the Cuff Link is not designed for arthroscopic use, so the authors slide a knot pusher down 1 of the sutures to push the device into place. Gentle taps with the mallet under arthroscopic visualization ensure that the device is securely seated.

At this point, the sutures are tensioned and tied. The repair construct is visualized from at least 2 angles to ensure a complete, stable repair (Video 5). The patient’s arm is placed in a sling, and he or she undergoes a standardized rehabilitation protocol.

**DISCUSSION**

Repair of the rotator cuff through transosseous tunnels has been a time-honored method since it was first described by McLaughlin\(^1\) in 1944. More recently, the proposed advantages of this technique have been debated against the benefits of suture anchor methods. Park et al\(^5\) used a bovine cadaveric model with pressure-sensitive film to show that simple, transosseous sutures had more contact area with a greater pressure over the footprint. They concluded that this may lead to stronger, faster...
rotator cuff healing. In a human cadaveric model, Ahmad et al showed significantly decreased motion at the repair site when using a similar transosseous suture technique with a 1-cm bone bridge. The motion was approximately 2 mm after suture anchor repair and 0.02 mm after the transosseous technique. In an in vivo sheep infraspinatus model, Lewis et al compared suture anchor repair with transosseous sutures and found a statistically significant increase in initial load to failure, but no significant difference was found when assessed at later time points.

Although Ahmad et al showed decreased motion using a transosseous technique after 10 cycles, in 2 earlier studies, Burkhart et al used hundreds of cycles to failure and showed that suture anchor constructs fail at considerably more cycles. The suture anchor specimens all exhibited failure at the suture–tendon junction, with only 1 also showing failure of the bony side. In contrast, when testing transosseous technique with a 2-cm bone bridge, the bone seems to be the key variable. Six of 15 specimens failed with the suture cutting through the bone bridge, and an additional 3 of 15 had this in addition to the suture pulling through the tendon. Six of 7 specimens with the lateral hole drilled through cortical bone failed with suture pulling through tendon, whereas 6 of 9 specimens with the lateral hole drilled through metaphyseal bone failed with the suture pulling through the bone.

For transosseous suture techniques, bone is a weak link, especially the lateral metaphyseal bone. High-resolution, micro-computed tomography studies have shown that the stronger bone is located adjacent to the articular surface medially and more distal to the apex of the greater tuberosity because the metaphysis blends into the diaphysis. Zheng et al used human cadaveric specimens to compare a transosseous technique with a 13-mm bone bridge with 2 different suture anchor configurations under cyclic loading to failure. The transosseous specimens tolerated significantly more cycles to failure than a double-row technique using corkscrew suture anchors. Similar to the findings of Burkhart et al, failure of the bone occurred in 5 of 19 lateral row failures—again significantly different than the suture anchor techniques. However, even more common were the 14 suture breakages, compared with only 1 observation of this failure mode in the studies by Burkhart et al. It is presumed that abrasion of the suture with the bone either cuts through the bone or abrades through the suture. This phenomenon has been studied in detail by Kowalsky et al, who tested various suture types and noted statistically significant differences in abrasion properties and consequently cycles to failure.

To supplement the lateral bone—the weak link in open transosseous repair—various augmentation devices have been used. Caldwell et al tested cadaveric humeri and showed that tying the lateral row over a high-density polyethylene suture button (Smith & Nephew Orthopaedics, Memphis, Tennessee) nearly doubled the ultimate tensile strength of the repair. An in vitro sheep testing model was used by Koh et al to show a 25% increase in ultimate tensile strength and lower failure rate when using a polyactic acid scaffold to augment the lateral cortex.

Gerber et al used an in vivo sheep rotator cuff repair model and showed that 8 of 16 transosseous repairs failed without augmentation, whereas none of the augmented specimens failed. They used an absorbable poly(L/D-lactide) plate (G. HUG, Freiburg-Umkirch, Germany) and noted that they now use a thin titanium Button Plate (Synthes, Paoli, Pennsylvania) clinically for lateral cortical augmentation.

Despite the interest in augmenting the lateral bone bridge in open rotator cuff repairs, to the authors’ knowledge, this is the first description of arthroscopic bone tunnel augmentation. Although the technique is possible using the same implants used for open surgery, with readily available arthroscopic instruments (knot pusher), new devices are currently being developed specifically for arthroscopic delivery and augmentation of bone tunnels.

**Conclusion**

Bone tunnel augmentation for open rotator cuff repair using transosseous sutures has been previously described and used successfully. The decreased overall cost to the health care system when transosseous techniques are used may tip the scales where the basic science and clinical efficacy debate continues.

Arthroscopic transosseous rotator cuff repair appears to harness the promising features of the open technique: clinical success, footprint reconstruction, static load to failure, cyclic load to failure, and motion at the repair site. It can also be expected to have the same shortcomings: suture cutout through bone and bone abrasion with suture breakage.

These clinical issues have been addressed for open transosseous rotator cuff repair by using bone tunnel augmentation devices, stronger suture materials, larger diameter sutures, or a combination thereof. Because the underlying principles for suture cutout at the bone interface are the same, the authors believe that application of bone tunnel augmentation to arthroscopic transosseous rotator cuff repair may also be beneficial, especially in situations where one could reasonably expect bone quality to be poor or in situations where poor bone quality is unexpectedly encountered intraoperatively.

**References**


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