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Arthroscopic Double-Row Rotator Cuff Repair Using a Knotless, Interconnected Technique ☆

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The surgical techniques used for rotator cuff repair have evolved over the past 3 decades. Technical innovations have contributed to improved clinical outcomes following repair. Recently, double-row repairs have demonstrated substantial biomechanical advantages when compared with single-row repairs, including decreased gap formation, increased ultimate load to failure, and improved footprint coverage. Knotless transosseous equivalent rotator cuff repair has emerged as an alternative to knotted constructs. The lack of medial knots with the knotless repairs is thought to improve vascular inflow, and the wider suture materials may prevent suture cut through of the repaired cuff tendon. Furthermore, knotless techniques may decrease operative time and may eliminate postoperative knot impingement within the subacromial space. This article serves to highlight our preferred surgical technique for the knotless double-row, transosseous equivalent rotator cuff repair and to review the current literature pertaining to the clinical outcomes following knotless and knotted repair constructs.

KEYWORDS rotator cuff, knotless, double row, technique

Introduction

Arthroscopic rotator cuff repair is a well-established means for alleviating shoulder pain and restoring function in patients with rotator cuff tears who have failed nonoperative management.[1,2] The indications for rotator cuff repair have drastically changed over the last 3 decades in part owing to innovations in surgical technique and improved clinical outcomes. Although short-term outcomes following arthroscopic rotator cuff repair have consistently demonstrated outstanding pain relief, significant concerns exist regarding the ability for the torn rotator cuff to heal and function effectively over the long term.[1-5]

The precise etiologies related to poor cuff tendon healing for some rotator cuff repair constructs are not fully understood; however, it is theorized that mechanical factors, coupled with an optimal biologic healing environment, are critical to achieve strong tendon to bone healing.[6,7] In addition, it is believed that accurate restoration of the native footprint may enhance healing potential as a result of favorable biomechanical and biochemical conditions.[8] Recently double-row repairs have been found to provide distinct biomechanical advantages such as decreased gap formation, increased ultimate load to failure, and improved footprint coverage when compared with single-row repairs. Moreover, transosseous equivalent rotator cuff repair methods (ie, suture bridging repairs) have improved on these advantages even further.[9] Although these benefits are well substantiated, transosseous equivalent repairs are technically more challenging and may be associated with increased operative times and implant costs when compared with single-row repairs.[10]

Knotless transosseous equivalent repair has emerged as an alternative to knotted constructs that require the placement of

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arthroscopic knots medially near the musculotendinous junction.

In this review, our preferred technique for double-row, transosseous equivalent rotator cuff repair using a knotless technique is presented. It can be noted that this technique allows for restoration of the anatomical footprint using a durable double-row suture bridge configuration, suture tape for increased strength and decreased pullout, self-reinforcement using suture interconnectivity, and efficiency using a knotless system.

Evolution of Rotator Cuff Repair Techniques

It has been proven that arthroscopic repair of full-thickness rotator cuff tears provides significant pain relief and improves shoulder function in most symptomatic patients. However, despite excellent clinical results, retear rates remain elevated, which has raised concerns regarding the long-term outcomes following rotator cuff repair.[5,11-14] Numerous studies have since evaluated the modes of failure for various rotator cuff repair constructs in an effort to identify techniques that may decrease retear rates and optimize long-term clinical outcomes.

In the past, failure of the repair construct was the most frequent cause of recurrent rotator cuff tendon defects. These included failure at the suture-anchor interface,[15,16] the bone-anchor interface,[17-19] and the arthroscopic knot.[20-23] This led to numerous studies that aimed to improve the overall strength of rotator cuff repair constructs. For example, single-row repairs, which typically use simple sutures passed through the reduced cuff secured with 2 lateral anchors, showed decreased footprint contact area,[24-26] decreased footprint compression,[7,27-29] decreased ultimate load to failure,[6,30-32] and increased gap formation[30,31,33] when compared with double-row repairs, which involve the placement of additional suture anchors and mattress sutures medially near the musculotendinous junction.

A recent meta-analysis of 7 level I randomized trials that compared the results of single- and double-row repair found a significantly increased relative risk of cuff retears following single-row repair, although there were no differences in clinical outcomes scores between treatment groups after a mean follow-up period of 23.2 months.[13] However, the investigators pointed to several studies suggesting that asymptomatic cuff retears may require more than 24 months to become clinically apparent if tear progression was to occur.[34,35] Therefore, it was postulated that differences in clinical outcomes scores between single- and double-row repairs may have been more robust if the duration of follow-up had been extended beyond 2 years. This hypothesis was supported in a study by Denard et al[36] in which improved clinical outcomes were found following double-row repair when compared with single-row repair after a minimum 5-year follow-up period.

As a result of favorable clinical and biomechanical evidence, the preferred technique for rotator cuff tears evolved from a single- to a double-row method. However, clinicians and researchers were still observing retear rates up to 30% following double-row rotator cuff repair. Therefore, in an effort to improve structural integrity, standard double-row repair techniques were further modified into more anatomical suture bridging constructs in which medial suture limbs are interconnected with lateral suture anchors to help compress the tendon back to its native footprint.[37] Several studies found that suture bridging techniques were biomechanically superior to standard single- and double-row repairs with regard to rotational load sharing, footprint coverage, footprint compression, gap formation, and ultimate load to failure.[8,9,27,28,31,32,38] This method of cuff repair allows for the placement of suture anchors in an area of superior bone quality and also away from the tendon-bone interface where healing occurs.[39,40] In addition, suture bridge repairs also demonstrated self-reinforcement in which the grasping strength of the repair construct increased as the humerus was mobilized via contraction of the rotator cuff musculature.[41,42]

With recent advancements in arthroscopic techniques and increased biomechanical strength of sutures and suture anchors, failure of cuff tissue at the suture-tendon interface has now become one of the primary mechanisms of repair failure.[22,43-46] In particular, suture cut through has been observed laterally following single-row repairs (simple sutures)[4] and medially following standard double-row and transosseous equivalent repairs (horizontal mattress sutures).[3,47-49] Several theories have been proposed to explain this mode of cuff failure including stress concentration at the location of medial knots,[25,49] high forces per unit area of cuff tissue owing to the high strength and small diameter of standard suture materials,[33,45,50] impedance of vascular inflow due to overtensioning of medial knots,[3,51] and potentially the promotion of suture cut through owing to the small elastic modulus inherent to standard suture materials.[52-54]

Owing to these concerns, suture bridging constructs that use knotless medial anchors with interconnected suture tapes have been developed to help improve the healing potential of the repaired cuff.[2] Specifically, the lack of medial knots is thought to improve vascular inflow, and the wider suture material is thought to prevent suture cut through by spreading the force of compression over a larger surface area of the repaired cuff tendon. In addition, knotless techniques may decrease operative time[41] while also avoiding the potential for postoperative knot impingement[55] within the subacromial space.

Knotless Double-Row Repair: Surgical Technique

The decision to perform arthroscopic rotator cuff tear is made following standard approaches to clinical evaluation and appropriate patient selection. Following the administration of a regional interscalene block and the induction of anesthesia, the patient is placed in the modified beach-chair position and the affected arm is secured in a pneumatic arm holder. The shoulder is prepared using sterile technique and draped free to