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Current concepts in the evolution of arthroscopic rotator cuff repair

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A R T I C L E I N F O

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Arthroscopic rotator cuff repair has become one of the most common and successful surgeries performed in orthopedics. It represents the culmination of advances in many diverse fields such as optics, fluid dynamics, mechanical engineering, and most recently, orthobiologics. This article reviews the current state of the art of arthroscopic rotator cuff repair, through the lens of its historical context and evolution to our present understanding. We review the limitations in the current approach, and glance toward the future of rotator cuff regeneration with emerging technologies.

Arthroscopic rotator cuff repair (RCR) has evolved into one of the most common orthopedic surgical procedures worldwide. This evolution has been made possible by innovations in a broad diversity of fields including optics, anatomy, mechanical engineering, and biologics. In spite of these advancements, there is still much work to be carried out to improve healing rates, outcomes, and long-term durability in this pathology. The purpose of this article is to summarize the current state of the art in arthroscopic RCR in terms of techniques, outcomes, and continued challenges.

History

The first known description of a rotator cuff tear dates back to 1788 when Monro depicted a tear in the supraspinatus and infraspinatus in his book, “A description of All the Bursal Mucosae of the Human Body”.[75] Attempts at surgical repair, however, were extremely rare before the early 20th century. Perthes, in 1906 reported a series of 3 RCRs,[82] and Codman reported his surgical technique to repair supraspinatus ruptures in 2 cases in 1911.[28]

Around this same time, endoscopy was beginning to be explored. In 1912, the Danish surgeon Nordentoft examined a series of cadaveric knee joints with an endoscope,[57] and in Japan Takagi used knee arthroscopy to evaluate tuberculosis in 1918.[99] The first known arthroscopic series on live patients is credited to the Swiss surgeon Bircher, when he reported on a series of 21 knee arthroscopies in 1922.[56] The shoulder would be slow to follow. In 1931, Burman performed a series of cadaveric diagnostic arthroscopies in the shoulder and correlated his findings after opening the specimens.[22] It would be another 50 years, however, until shoulder arthroscopy was adopted for clinical use. The first clinical report of shoulder arthroscopy in the United States was by Andrews, reporting on its use in the management of partial-thickness tears of the rotator cuff in 1985.[1] A number of early pioneers such as Burkhart, Esch, Abrams, Bell, and Savoie were in collaborative discussions on the feasibility of using the arthroscope to perform RCR in the early 1990s, but it was Snyder who first presented the technique of arthroscopic RCR.[96]

Technical advancements

Tendon mobilization

To arrive at the modern arthroscopic RCR required significant technological innovations in visualizing the pathology, mobilizing the retracted tendon or tendons, and reattaching it to bone. It has long been recognized that over tensioning a rotator cuff tear is detrimental to healing.[32,80] One of the primary goals of arthroscopic RCR is to perform adequate releases of the retracted rotator cuff tendons. Initially, the tissue inferior to the cuff is released from a contracted capsulolabral complex. It is important to recognize that a torn retracted rotator cuff often becomes scarred down anteriorly to the retracted corocohumeral ligament and tissues of the rotator interval. Tauro[100] described the technique of the arthroscopic interval slide, whereby massive retracted and immobile supraspinatus tears are released from the interval tissue and repaired to the native footprint without significant tension. He

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published a clinical study on 43 patients with 32 months follow-up demonstrating good or excellent results.[101] Lo and Burkhart published their results on interval slides including a "posterior interval slide" whereby the interval between the supraspinatus and infraspinatus is released along the spine of the scapula, allowing individual mobilization of the two tendons and improved tension on massive repairs,[64] and reported satisfactory results in 8 of 9 patients. A more recent follow-up study by Berdusco and Lo,[7] however, reported on the clinical outcomes in 15 patients who required interval slides to complete the repair. While their clinical outcomes did show improvement, their retear rate by MRI at 2 years showed retears to the original size in 55% of patients. The authors recommended this procedure as a salvage operation in the setting of massive immobile and retracted tears.

Even with the best of mobilization techniques, it is often that the torn edge of a rotator cuff tear cannot be mobilized to reach the articular margin of the rotator cuff insertional footprint. Sometimes tears fall short of the footprint but can be successful with medialization. This was a challenge for open surgeons as well. Open surgery taught us to mobilize the cuff which translated into arthroscopic repair… In 1965, Debeyre et al published a technique of supraspinatus advancement, whereby the supraspinatus was elevated from the fossa and translated laterally to reach the cuff footprint.[34] This technique has not been widely adopted. A second option is to medialize the cuff footprint by removing a section of the articular margin and attaching the rotator cuff medial to its normal insertion.[37,106] This is a quite simple procedure, and promising clinical results have been reported with this technique,[37,72] and has been a common technique used by the senior author. There is a limit to medialization, however, as cadaveric work has shown that medialization >10 mm results in a compromised range of motion.[106] The art of mobilizing the torn rotator cuff tendon is one of the most difficult learning curves for the arthroscopic shoulder surgeon. A properly mobilized tendon for a low tension repair remains, however, an absolute prerequisite for a successful RCR.

Suture anchors

Once the tendon is visualized and mobilized, it should be securely attached to the bone. This critical step has its own history and is told in the evolution of the suture anchor. The suture anchor is perhaps the single technology that has made the arthroscopic shoulder surgery adaptable to the masses. This innovation has also revolutionized the economics of shoulder surgery, providing a widget that has built companies, and allowed financial incentives to innovative surgeons and engineers that has resulted in an incredibly steep technology curve in the pursuit of the ideal surgical technique. The concept of the suture anchor is fairly straight forward: put a stitch through the torn tendon, and attach that stitch securely into the bone of the tuberosity. This simple concept, however, has proven anything but easy, with the guiding principles of secure bony fixation, minimal iatrogenic insertional damage, and prevention of longer term joint damage resulting in hundreds of different approaches.

The first suture anchor was invented by Goble and Somers in 1985 as the "Statak" suture.[102] They bonded a braided polyester suture to a headless hex screw, combining the versatility of suture and the strength and ease of a threaded screw.[44] Several subsequent studies showed that the pullout strength of these early anchors was equivalent to suture repairs and superior to tunnels through bone.[31,49,86] Thus the race began. The material of the implant, its size and design, and the ease of implantation, all became foci for innovative surgeons and companies alike. In 1995, F. Alan Barber published the first in a series of articles that would establish him as an authority on suture anchors.[4] He studied ultimate load with axial pull out to test a range of new to market anchors every few years for almost two decades. The results of these and other studies shaped the development of suture anchors.[102] In 1997, Burkhart suggested that the mode of failure, especially when applied to RCRs would be better done as cyclical loading instead of single load to failure. In two separate experiments, he tested the effect of cyclical loading on simulated cadaveric RCRs first with transosseous tunnels and then with anchors. His studies showed that suture anchors outperformed the transosseous tunnels and that in cyclical loading, which was a better approximation of the in vivo condition. In cyclical loading, transosseous tunnels failed by suture cutting through bone whereas the mode of failure in single load testing was suture breakage.[17,20] This led to one of many redesigns of suture anchors to minimize pull out from bone or failure at the junction of the suture/anchor interface (Fig. 1).[12]

Further advances in knotless technologies and all-suture suture anchors have continued to advance us toward what Burkhart called the "holy grail" of secure bony fixation, minimal iatrogenic insertional damage, and prevention of long-term joint damage. Over the past two decades, suture anchor advances have achieved the ultimate mechanical goal of shifting the mode of failure from the anchor and suture, to pull out of the suture through the tendon itself. This has led to a revolution in surgical techniques which continues to be debated today.

Suture techniques

In 1994, Gerber reported on the mechanical strength of repair techniques for the rotator cuff, in the first of his landmark studies utilizing the sheep infraspinatus as a model for RCR.[43] In it, he found that simple sutures through tendon were "mechanically poor" and recommended other suture grasping techniques to minimize the risk of suture pulling through the tendon. Burkhart demonstrated that simple mattress suture constructs were also less than satisfactory and emphasized multiple suture tails and load sharing techniques to minimize suture pull out through tendon.[16] More recently, Burkhart et al have described a "load sharing rip stop" repair construct.[15] This technique places simple sutures beyond a mattress suture that is placed in the torn rotator cuff, in a concept similar to the Mason-Allen stitch recommended by Gerber. Burkhart et al showed that not only did this construct improve failure loads by 1.7 times but demonstrated that mode of failure by suture pull out of tendon was nearly eliminated.[15] In spite of these advancements, recurrent tear rates have been a persistent shortcoming of RCR. One cited explanation for this is that repair of the torn tendon using a single row of anchors cannot restore the native anatomic footprint of the rotator cuff. Apreleva et al demonstrated that a single row of anchors only reconstituted 67% of the cuff footprint, which was significantly less than a transosseous technique which restored 85% of the footprint.[2] The authors suggested that a larger footprint of repair may potentially improve the healing and mechanical strength of repaired tendons and that this could be better achieved using a double row. Lo and Burkhart introduced the concept of the double-row RCR in which a single medial row of anchors is passed medial to the edge of the torn rotator cuff with mattress stitches, and a second lateral row of anchors is placed using simple sutures through the edge of the tendon. The authors proposed that such a technique would restore the medial-lateral footprint of the cuff. This technique has been modified where the limbs of the medial row of stitches are passed through the cuff and taken laterally on top of the residual lateral tendon, into suture anchors at the lateral margin of the footprint. This modification is known as the "transosseous equivalent" and it compresses the tendon against the native footprint.

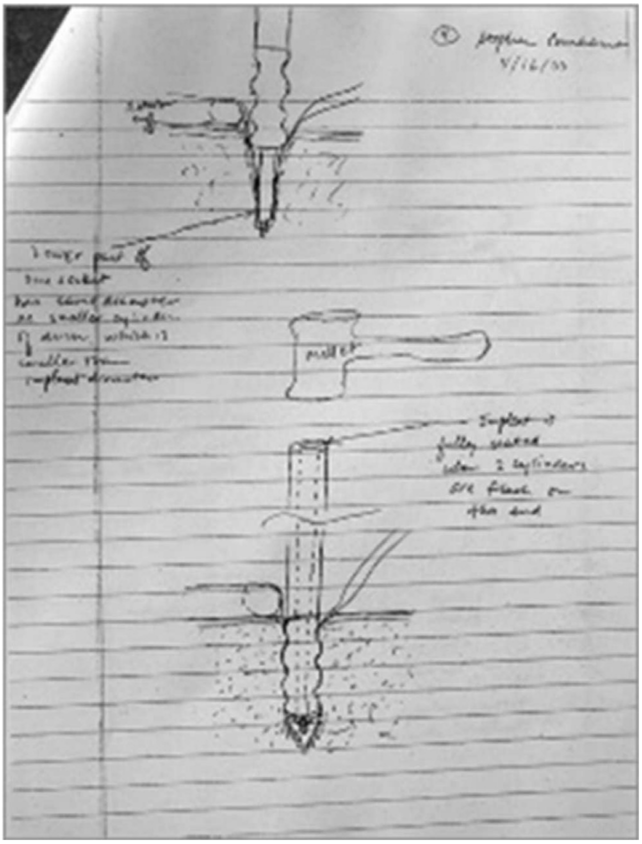

Figure 1 Burkhart's original drawing of a suture anchor from April 2000. Reprinted with permission.[12]

The appropriate type of repair that is performed remains controversial, but it is important to understand that the rotator cuff is a multilayered structure, and in addition to the classic description of tear types as U-shaped, L-shaped, and massive retracted tears,[18] more complex horizontal delamination tears of the articular and bursal surfaces may combine with these traditional tears.[25] A further complicating matter is that the deeper articular-sided layer in these tears often contains the rotator cable, which has been shown to be a critical structure to maintaining function[36] (Fig. 2).[12]

There have since been multiple studies comparing the biomechanics and clinical outcomes of both single-row and double-row techniques, as well as systematic reviews of the same[8] (Fig. 3).[79]

In single-row comparisons, most studies have shown that techniques that include an anterior to posterior stitch that is spanned by a medial to lateral stitch, such as the rip-stop, massive cuff stitch, lasso loop, and modified Mason-Allen outperform simple and mattress repair constructs.[48,67,85,93,95,105] In double-row techniques, the main comparisons are between traditional double-row techniques and transosseous equivalent techniques. These studies have failed to demonstrate a consistent biomechanical advantage of one technique over the other within the double-row group regarding contact area, contact pressure, gap formation, or stiffness.[6,9,59,61,63,77,91] The one exception seems to be that medial-row knot tying outperforms knotless medial-row constructs.[59,63] Kim et al[59] evaluated transosseous equivalent with medial-row knot tying vs. not tying and found that those with medial-row knot tying had significantly higher footprint contact area and interface pressure than those that were not tied. Leek et al[63] found that medial-row knot tying in transosseous RCRs resulted in significantly higher stiffness and lower displacement during cyclical loading.

Much more study has been devoted to comparing single- vs. double-row repair constructs.[5,39,47,65,69,70,78] In biomechanical analyses, studies show that double-row constructs result in consistently higher contact area[47,69,70] and contact pressure.[5,47] Ma et al demonstrated that double-row constructs improved ultimate tensile load,[65] whereas other studies by Esquivel[39] and Mazzocca[70] failed to demonstrate a difference in load to failure.

When comparing various techniques in the clinical setting, there have been at least 11 studies that have directly compared single- vs. double-row techniques for clinical and functional outcomes.[3,21,26,41,42,46,60,62,66,78,84] Of these studies, 8 of 11 showed no difference between single- and double-row repairs. Two studies[66,78] noted differences between groups, but these were for large tears (>3cm) only. Park et al[78] found that double-row repairs had higher American Shoulder and Elbow Surgeons scores, Constant scores, and Shoulder Strength Index scores than the single-row group. Ma et al[66] found that for large tears, muscle strength was improved in the double-row group.

Regarding studies that specifically compared double- vs. single-row repair for *healing rates* of RCR, 5 of 8 found no difference in healing.[21,41,60,66,84] For the 3 studies that did demonstrate a difference,[26,42,62] all favored the double-row construct. Gartsman[42] in a comparative study of 83 patients at 10 months found double-row suture bridge repair rates of failure at 7% which was significantly lower than the 25% rate of his single-row repairs with simple sutures. Lapner et al found that standard double-row repair was associated with higher MRI healing rates than single-row repair using mattress sutures.[62] Finally, Charousset et al demonstrated improved healing at 6 months in the double-row group (61%) compared with the single-row group (40%),[26] although both groups demonstrated high retear rates. One study comparing retear rates between single- and double-row repairs is important to bring up. Cho et al[27] compared the structural results after single- vs. double-row (suture bridge) repair. The suture bridge technique tended to have a lower retear rate than a single-row technique did; however, when there was a retear, the single row tended to avulse off of the bone, whereas the double row tore near the musculotendinous junction. This study raised speculation that a failed double-row repair might render a revision irreparable.

Finally, there have been several studies that have compared the clinical outcomes between double-row techniques. Kim et al found no difference in clinical outcomes or retear rates comparing standard double-row vs. transosseous techniques.[58] Rhee et al compared knotless suture bridge (with a medial-row Mason-Allen equivalent) with knotted medial-row suture bridge, and found that the knotless Mason-Allen suture bridge retear rate (6%) was significantly lower than the knotted suture bridge group (19%). Finally, Ryu et al[88] compared a traditional suture bridge construct with the addition of lateral-row stitches to repair dog ears and found that this adjunct improved healing rates over the standard suture bridge construct.

Other approaches

As RCRs were just beginning in the early 1990s, there were concerns about failure due to overstrain of these repairs. Burkhart described an arthroscopic tendon-to-tendon repair that was a modification of a similar technique by Codman.[29] Burkhart coined the term “margin convergence” in 1994”.[13] He theorized that side-to-side sutures in a massive cuff would act to decrease the medial to lateral length of the tear and thereby reduce the overall strain of the

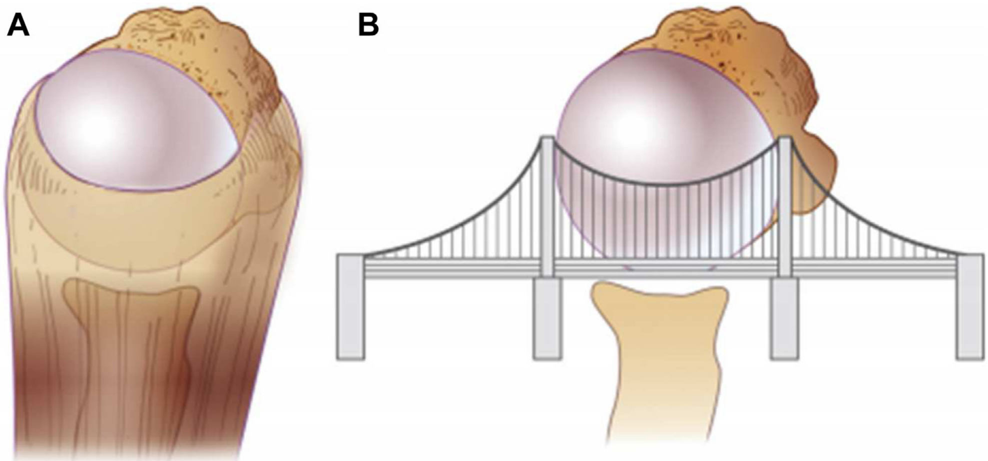

Figure 2 Burkhart's concept of the suspension bridge theory of rotator cuff repair. (**A**) Artist's rendition of a large rotator cuff tear, with an intact rotator "Cable". (**B**) Artist's rendition of a "suspension bridge" analogy, where the cable of the bridge is analogous to the rotator cuff's cable, distributing forces across the entire construct. Reprinted with permission.[12]

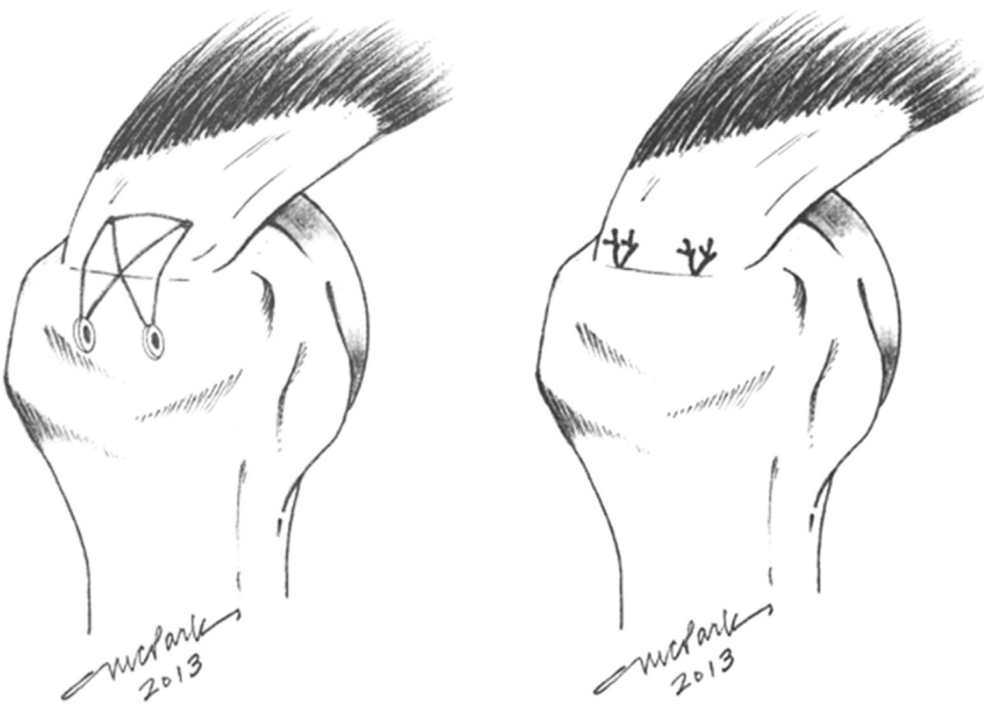

Figure 3 Transosseous equivalent double-row repair (left) and single-row repair with 2 double-loaded suture anchors with simple configurations (right). Reprinted with permission.[79]

repair construct. By reinforcing the margin of the cuff, the strain placed at the repair on the bone could be decreased. He later published his results in arthroscopic cuff repair, which included a subset of large U-shaped tears treated with margin convergence. He reported 95% good to excellent results across the series and that margin convergence repairs did just as well as those repaired to bone.[14] Margin convergence is now a well-accepted technique of approaching larger tears, and while it certainly helps to close the defect, it is important to recognize the biomechanical advantages of this technique on reducing strain on RCRs.

The partial thickness tear

The treatment of partial-thickness rotator cuff tears (PTRCTs) has been improved by arthroscopy. It has become the gold standard for diagnosis of partial-thickness tears,[33] and in the case of articular-sided tears, has allowed assessment, débridement, and repair without taking down the intact bursal side, which is necessary in open approaches. Partial-thickness subscapularis tears and so-called "hidden lesions" of the biceps pulley can be diagnosed and treated without violation of the superficial cuff and interval tissue.[103] Partial-thickness tears were originally classified by Ellman,[38] in terms of location (articular, bursal, and intratendinous) and by size of a tear (<3 mm, 3-6 mm, >6 mm). This classification continues to be widely quoted as the size of the grade 3 (>6 mm) tear generally corresponds to the "50%" trigger for operative repair recommendations. Weber[104] reported a retrospective series of PTRCTs involving >50% thickness of the tendon. They demonstrated superior outcomes in patients after RCR versus rotator cuff débridement and found that débridement never resulted in healing of these lesions. There are several variations on the approach to the arthroscopic management of PTRCTs. One is whether or not acromioplasty should be concurrently performed. Acromioplasty has long been a successful method of treatment in open RCRs in the hands of the senior author. Ellman's original study of PTRCTs agreed with this, reporting 88% good and excellent results with arthroscopic débridement combined with acromioplasty, noting it a viable option for patients with PTRCTs. Other authors, however, have demonstrated no clear benefit to the addition of a subacromial decompression or acromioplasty.[97,98] While débridement may be effective for lower-grade PTRCTs, <50%, this may be variable depending on location. Cordasco et al[30] reported good results in patients with PTRCTs treated with débridement but found that bursal-sided tears had a much higher failure rate (29%) than articular-sided tears (3%), which led the authors to recommend completion of the tear with subsequent repair for bursal-sided lesions. Other studies have shown that arthroscopic débridement alone does not necessarily prevent progression of a PTRCT to a full-thickness tear. Kartus et al reported this to be the case in 35% of their patients at a mean of 101 months.[55] Thus, in significant PTRCTs, repair is the treatment of choice.

Repair of the PTRCT can be accomplished either by conversion of the tear to a full-thickness tear and repairing the entire construct (a "conversion" repair), or by repairing only the torn portion "in situ" without disturbing the intact tendon fibers. Both techniques have provided good to excellent results[24,52,54] in clinical studies. Comparative studies between conversion and in situ repair techniques have shown biomechanical advantages in the in situ constructs,[45,83] but clinical studies have failed to demonstrate an outcome advantage of either technique over the other.[23,94] Franceschi et al[40] performed a randomized clinical trial comparing conversion vs. in situ repair and specifically looked at retear rates, demonstrating no difference between the two techniques.

The irreparable tear

Unfortunately, some rotator cuff tears cannot be repaired with native tissue, and strategies to approach these tears have become the subject of increased attention. The simplest form of treatment is débridement, which was originally described in an open procedure by Rockwood in 1995.[87] Several arthroscopic techniques have been reported to include subacromial decompressions, biceps tenotomies, and rotator cuff débridements.[10,103] These techniques have reported reasonable clinical outcomes especially in the setting where patients had preserved shoulder motion preoperatively. Burkhart reported on a series of partial RCRs, with surprisingly good results. Patients improved UCLA scores from 10 to 28 and had an average strength gain of 2.3 grades.[19] A recent systematic review evaluated 11 studies on 643 partial repairs.[68] The authors' findings confirmed Burkhart's original study, in that all studies reported improved functional outcomes and strength. They did note a nearly 50% retear rate on average, but concluded this technique to be a useful approach in the setting of the massive irreparable rotator cuff tear.

Augmentation

In spite of the reported clinical success of partial repairs, the quest to complete a repair in the absence of sufficient tissue has led to an increased interest in augmenting or even spanning the RCR. This concept, like most in surgery, is not new. Neviaser et al[76] used freeze-dried allograft rotator cuff tendons attempt to reconstruction in 1978. The authors reported good or excellent functional results in 14 of 16 patients. The modern arthroscopic equivalent of this was described by Snyder et al,[11] wherein he used a human dermal allograft to augment arthroscopic RCR. The authors reported on 16 patients at a minimum 1-year follow-up and reported significant improvements in pain and function. In addition, 13 of 16 showed tissue incorporation by MRI. This technique can be considered an extension graft for the rotator cuff.

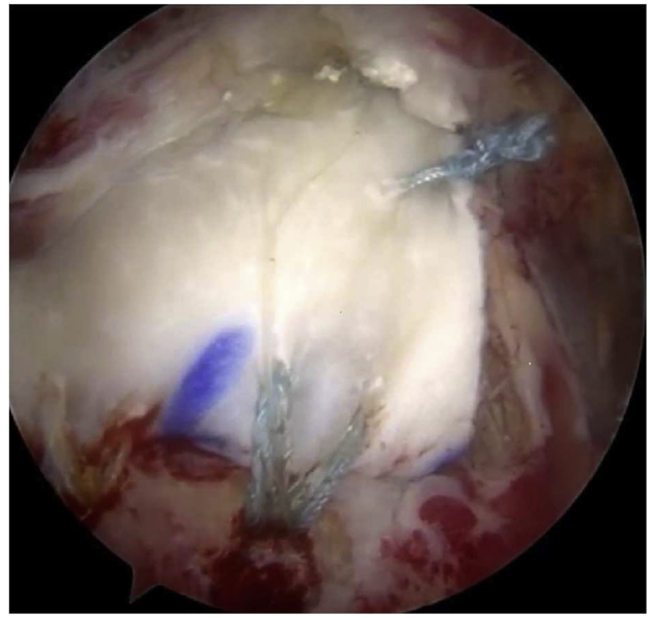

Figure 4 Superior capsule reconstruction for irreparable rotator cuff tear. (Tokish, personal photo).

Perhaps the most popular recent advance in the area of arthroscopic RCR augmentation is in the form of the superior capsular reconstruction (Fig. 4).

Described by Mihata in 2012,[74] the technique uses an autograft tensor fascia lata attached from the glenoid to the greater tuberosity, mimicking the superior capsule of the shoulder. He has reported excellent clinical and structural results at 5-year follow-up, with a low (10%) retear rate.[73] Other authors have modified the technique to using human dermal allograft, and have reported promising clinical results,[35,81] but further study in defining indications, techniques, and applications is necessary.

Other attempts at augmentative scaffolds have included xenograft scaffolds (Fig. 5[92]) extracellular matrix–based structures, synthetic scaffolds, or hybrids of the two. Most recently, nanotechnology has led to a technique called electrospinning whereby a synthetic, biodegradable scaffold can be created that mimics the orientation of the collagen fibers, and may incorporate biological components such as growth factors or medicinal signaling cells to foster biocompatibility and improved biomechanical properties[89,90] (Fig. 6).

The concept of biologically enhancing RCR comes from the fact that in spite of improved mechanical techniques of repair, studies have noted that retears have not significantly improved.[71] In response, biologic approaches to tendon regeneration have exponentially increased. Intriguing approaches such as platelet-rich plasma (PRP), growth factors, amniotic augmentation (Fig. 7), and medicinal signaling cells (MSCs) have all been applied to arthroscopic RCR with varying results. In vitro studies of PRP on rotator cuff torn tendons show that platelet growth factors may enhance proliferation of tenocytes and extracellular matrix synthesis.[51,53] Clinically, there have now been more than 20 randomized clinical

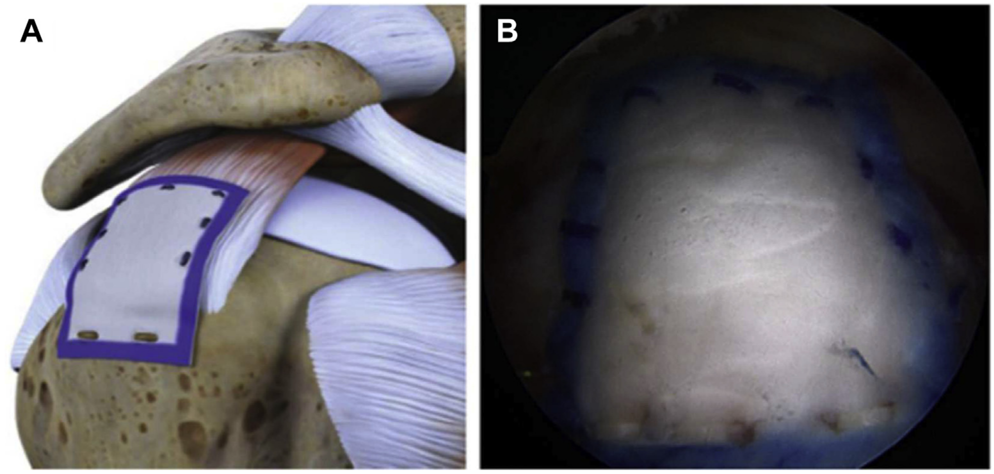

Figure 5 Xenograph scaffold for augmentation of rotator cuff repair.[2]

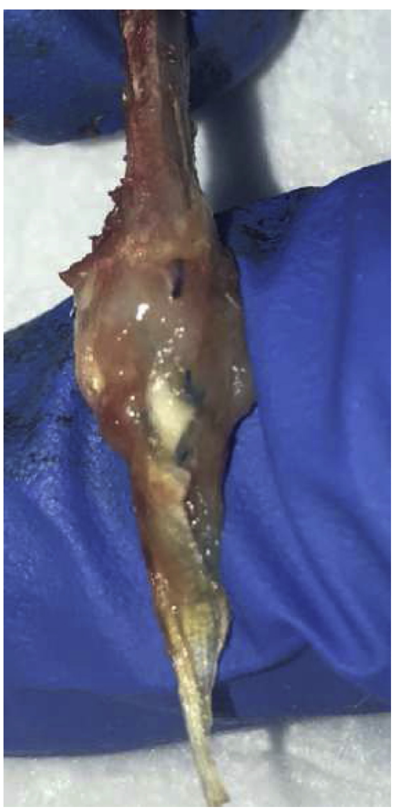

Figure 6 Electrospun patch at 4 weeks incorporation in a rat model.

trials on PRP use in the setting of arthroscopic RCR. A recent meta-analysis of 18 of these studies revealed that PRP improves healing rates (17 vs. 31% retear in the PRP vs. control group, respectively) as well as pain levels and functional outcomes, although the latter measures were not always clinically significant.

So-called "stem cell therapy" has also been recently suggested as a biological augment to RCR. Mesenchymal stem cells (now renamed medicinal signaling cells, or MSCs) may be a promising solution as they may provide augmentation directly at the repair site and stimulate local cells via paracrine signaling. Two clinical

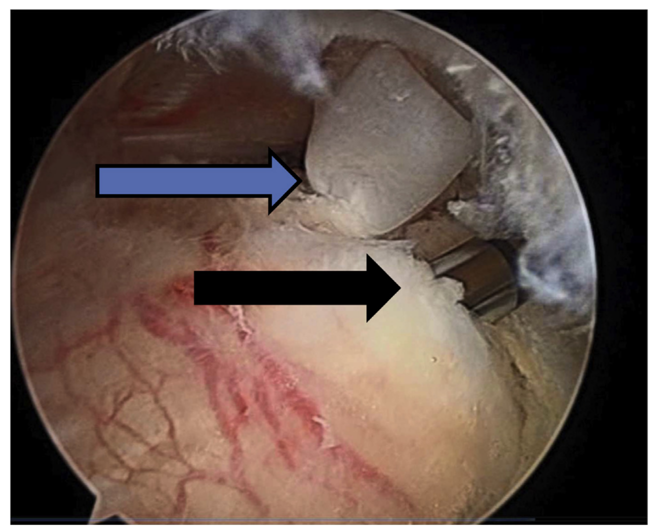

Figure 7 Amnion streamer delivered into partial-thickness cuff tear. *Blue arrow:* tail emerging from 40 mm inserted amnion streamer within the cuff. *Black arrow:* Amnion inserter in place with second streamer being deployed.

studies have been published using bone marrow concentrate. Hernigou et al[50] reported that this augmentation of RCRs improved healing rates at 10 years from 44% in standard RCRs to 87% in MSC augmented repairs. Many new techniques of biologic enhancement including exosomes, amniotic tissue, and tissue engineered hybrids are being explored.

Conclusions

Arthroscopic RCR has been established to alleviate pain and restore function in a minimally invasive and efficient fashion. Its rise to prominence has been enabled by the advancements in several technological fields including biomaterials, optics, and advances in minimally invasive surgical techniques. The ultimate outcome after RCR, however, remains elusive, in that retear rates still remain an area of concern. The rise in biologic strategies to address these challenges has shown initial promise but further work in other allied fields such as nanotechnology, biomaterials, and our basic science understanding of tissue regeneration is critical to solving this debilitating condition.

Conflicts of interest

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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References

1. Andrews JR, Broussard TS, Carson WG. Arthroscopy of the shoulder in the management of partial tears of the rotator cuff: a preliminary report. Arthroscopy 1985;1:117-22.
2. Apreleva M, Ozbaydar M, Fitzgibbons PG, Warner JJ. Rotator cuff tears: the effect of the reconstruction method on three-dimensional repair site area. Arthroscopy 2002;18:519-26. https://doi.org/10.1053/jars.2002.32930.
3. Aydin N, Kocaoglu B, Guven O. Single-row versus double-row arthroscopic rotator cuff repair in small- to medium-sized tears. J Shoulder Elbow Surg 2010;19:722-5. https://doi.org/10.1016/j.jse.2009.11.053.
4. Barber FA, Herbert MA, Click JN. The ultimate strength of suture anchors. Arthroscopy 1995;11:21-8.
5. Baums MH, Spahn G, Steckel H, Fischer A, Schultz W, Klinger HM. Comparative evaluation of the tendon-bone interface contact pressure in different single- versus double-row suture anchor repair techniques. Knee Surg Sports Traumatol Arthrosc 2009;17:1466-72. https://doi.org/10.1007/s00167-009-0771-7.
6. Behrens SB, Bruce B, Zonno AJ, Paller D, Green A. Initial fixation strength of transosseous-equivalent suture bridge rotator cuff repair is comparable with transosseous repair. Am J Sports Med 2012;40:133-40. https://doi.org/10.1177/0363546511426071.
7. Berdusco R, Trantalis JN, Nelson AA, Sohmer S, More KD, Wong B, et al. Arthroscopic repair of massive, contracted, immobile tears using interval slides: clinical and MRI structural follow-up. Knee Surg Sports Traumatol Arthrosc 2015;23:502-7. https://doi.org/10.1007/s00167-013-2683-9.
8. Bishop ME, MacLeod R, Tjoumakaris FP, Hammoud S, Cohen SB, Dodson CC, et al. Biomechanical and clinical comparison of suture techniques in arthroscopic rotator cuff repair. JBJS Rev 2017;5:e3. https://doi.org/10.2106/JBJS.RVW.17.00019.
9. Bisson LJ, Manohar LM. A biomechanical comparison of transosseous-suture anchor and suture bridge rotator cuff repairs in cadavers. Am J Sports Med 2009;37:1991-5. https://doi.org/10.1177/0363546509336260.
10. Boileau P, Baque F, Valerio L, Ahrens P, Chuinard C, Trojani C. Isolated arthroscopic biceps tenotomy or tenodesis improves symptoms in patients with massive irreparable rotator cuff tears. J Bone Joint Surg Am 2007;89:747-57. https://doi.org/10.2106/JBJS.E.01097.
11. Bond JL, Dopirak RM, Higgins J, Burns J, Snyder SJ. Arthroscopic replacement of massive, irreparable rotator cuff tears using a GraftJacket allograft: technique and preliminary results. Arthroscopy 2008;24:403-409 e401. https://doi.org/10.1016/j.arthro.2007.07.033.
12. Burkhart SS. Shoulder arthroscopy: a bridge from the past to the future. J Shoulder Elbow Surg 2020;29:e287-96. https://doi.org/10.1016/j.jse.2020.04.011.
13. Burkhart SS, Athanasiou KA, Wirth MA. Margin convergence: a method of reducing strain in massive rotator cuff tears. Arthroscopy 1996;12:335-8.
14. Burkhart SS, Danaceau SM, Pearce CE Jr. Arthroscopic rotator cuff repair: Analysis of results by tear size and by repair technique-margin convergence versus direct tendon-to-bone repair. Arthroscopy 2001;17:905-12.
15. Burkhart SS, Denard PJ, Konicek J, Hanypsiak BT. Biomechanical validation of load-sharing rip-stop fixation for the repair of tissue-deficient rotator cuff tears. Am J Sports Med 2014;42:457-62. https://doi.org/10.1177/0363546513516602.
16. Burkhart SS, Fischer SP, Nottage WM, Esch JC, Barber FA, Doctor D, et al. Tissue fixation security in transosseous rotator cuff repairs: a mechanical comparison of simple versus mattress sutures. Arthroscopy 1996;12:704-8.
17. Burkhart SS, Johnson TC, Wirth MA, Athanasiou KA. Cyclic loading of transosseous rotator cuff repairs: Tension overload as a possible cause of failure. Arthroscopy 1997;13:172-6.
18. Burkhart SS, Lo IK. Arthroscopic rotator cuff repair. J Am Acad Orthop Surg 2006;14:333-46. https://doi.org/10.5435/00124635-200606000-00003.
19. Burkhart SS, Nottage WM, Ogilvie-Harris DJ, Kohn HS, Pachelli A. Partial repair of irreparable rotator cuff tears. Arthroscopy 1994;10:363-70.
20. Burkhart SS, Pagan JLD, Wirth MA, Athanasiou KA. Cyclic loading of anchor-based rotator cuff repairs: Confirmation of the tension overload phenomenon and comparison of suture anchor fixation with transosseous fixation. Arthroscopy 1997;13:720-4.
21. Burks RT, Crim J, Brown N, Fink B, Greis PE. A prospective randomized clinical trial comparing arthroscopic single- and double-row rotator cuff repair: magnetic resonance imaging and early clinical evaluation. Am J Sports Med 2009;37:674-82. https://doi.org/10.1177/0363546508328115.
22. Burman MS. Arthroscopy or the direct visualization of joints: an experimental cadaver study. 1931. Clin Orthop Relat Res 2001:5-9.
23. Castagna A, Borroni M, Garofalo R, Rose GD, Cesari E, Padua R, et al. Deep partial rotator cuff tear: transtendon repair or tear completion and repair? A randomized clinical trial. Knee Surg Sports Traumatol Arthrosc 2015;23:460-3. https://doi.org/10.1007/s00167-013-2536-6.
24. Castricini R, Panfoli N, Nittoli R, Spurio S, Pirani O. Transtendon arthroscopic repair of partial-thickness, articular surface tears of the supraspinatus: results at 2 years. Chir Organi Mov 2009;93(Suppl 1):S49-54. https://doi.org/10.1007/s12306-009-0002-x.
25. Cha SW, Lee CK, Sugaya H, Kim T, Lee SC. Retraction pattern of delaminated rotator cuff tears: dual-layer rotator cuff repair. J Orthop Surg Res 2016;11:75. https://doi.org/10.1186/s13018-016-0407-9.
26. Charousset C, Grimberg J, Duranthon LD, Bellaiche L, Petrover D. Can a double-row anchorage technique improve tendon healing in arthroscopic rotator cuff repair?: A prospective, nonrandomized, comparative study of double-row and single-row anchorage techniques with computed tomographic arthrography tendon healing assessment. Am J Sports Med 2007;35:1247-53. https://doi.org/10.1177/0363546507301661.
27. Cho NS, Yi JW, Lee BG, Rhee YG. Retear patterns after arthroscopic rotator cuff repair: single-row versus suture bridge technique. Am J Sports Med 2010;38:664-71. https://doi.org/10.1177/0363546509350081.
28. Codman EA. Complete rupture of the supraspinatus tendon; operative treatment with report of two successful cases. Boston Med Surg J 1911;164:708-10.
29. Codman EA. The Shoulder: Rupture of the Supraspinatus tendon and other lesions in or about the subacromial bursa. Boston: Thomas Todd; 1934.
30. Cordasco FA, Backer M, Craig EV, Klein D, Warren RF. The partial-thickness rotator cuff tear: is acromioplasty without repair sufficient? Am J Sports Med 2002;30:257-60. https://doi.org/10.1177/03635465020300021801.
31. Craft DV, Moseley JB, Cawley PW, Noble PC. Fixation strength of rotator cuff repairs with suture anchors and the transosseous suture technique. J Shoulder Elbow Surg 1996;5:32-40.
32. Davidson PA, Rivenburgh DW. Rotator cuff repair tension as a determinant of functional outcome. J Shoulder Elbow Surg 2000;9:502-6.
33. de Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. AJR Am J Roentgenol 2009;192:1701-7. https://doi.org/10.2214/AJR.08.1241.
34. Debeyre J, Patie D, Elmelik E. Repair of ruptures of the rotator cuff of the shoulder. J Bone Joint Surg Br 1965;47:36-42.
35. Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary results of arthroscopic superior capsule reconstruction with dermal allograft. Arthroscopy 2018;34:93-9. https://doi.org/10.1016/j.arthro.2017.08.265.
36. Denard PJ, Koo SS, Murena L, Burkhart SS. Pseudoparalysis: the importance of rotator cable integrity. Orthopedics 2012;35:e1353-7. https://doi.org/10.3928/01477447-20120822-21.
37. DeOrio JK, Cofield RH. Results of a second attempt at surgical repair of a failed initial rotator-cuff repair. J Bone Joint Surg Am 1984;66:563-7.
38. Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. Clin Orthop Relat Res 1990:64-74.
39. Esquivel AO, Duncan DD, Dobrasevic N, Marsh SM, Lemos SE. Load to failure and stiffness: anchor placement and suture pattern effects on load to failure in rotator cuff repairs. Orthop J Sports Med 2015;3:2325967115579052. https://doi.org/10.1177/2325967115579052.
40. Franceschi F, Papalia R, Del Buono A, Vasta S, Costa V, Maffulli N, et al. Articular-sided rotator cuff tears: which is the best repair? A three-year prospective randomised controlled trial. Int Orthop 2013;37:1487-93. https://doi.org/10.1007/s00264-013-1882-9.
41. Franceschi F, Ruzzini L, Longo UG, Martina FM, Zobel BB, Maffulli N, et al. Equivalent clinical results of arthroscopic single-row and double-row suture anchor repair for rotator cuff tears: a randomized controlled trial. Am J Sports Med 2007;35:1254-60. https://doi.org/10.1177/0363546507302218.
42. Gartsman GM, Drake G, Edwards TB, Elkousy HA, Hammerman SM, O'Connor DP, et al. Ultrasound evaluation of arthroscopic full-thickness supraspinatus rotator cuff repair: single-row versus double-row suture bridge (transosseous equivalent) fixation. Results of a prospective, randomized study. J Shoulder Elbow Surg 2013;22:1480-7. https://doi.org/10.1016/j.jse.2013.06.020.
43. Gerber C, Schneeberger AG, Beck M, Schlegel U. Mechanical strength of repairs of the rotator cuff. J Bone Joint Surg Br 1994;76:371-80.
44. Goble EM, Somers WK, Clark R, Olsen RE. The development of suture anchors for use in soft tissue fixation to bone. Am J Sports Med 1994;22:236-9.
45. Gonzalez-Lomas G, Kippe MA, Brown GD, Gardner TR, Ding A, Levine WN, et al. In situ transtendon repair outperforms tear completion and repair for partial articular-sided supraspinatus tendon tears. J Shoulder Elbow Surg 2008;17:722-8. https://doi.org/10.1016/j.jse.2008.01.148.
46. Grasso A, Milano G, Salvatore M, Falcone G, Deriu L, Fabbriciani C. Single-row versus double-row arthroscopic rotator cuff repair: a prospective randomized

clinical study. Arthroscopy 2009;25:4-12. https://doi.org/10.1016/j.arthro.2008.09.018.
47. Grimberg J, Diop A, Kalra K, Charousset C, Duranthon LD, Maurel N. In vitro biomechanical comparison of three different types of single- and double-row arthroscopic rotator cuff repairs: analysis of continuous bone-tendon contact pressure and surface during different simulated joint positions. J Shoulder Elbow Surg 2010;19:236-43. https://doi.org/10.1016/j.jse.2009.09.006.
48. Hapa O, Barber FA, Sunbuloglu E, Kocabey Y, Sarkalkan N, Baysal G. Tendon-grasping strength of various suture configurations for rotator cuff repair. Knee Surg Sports Traumatol Arthrosc 2011;19:1749-54. https://doi.org/10.1007/s00167-010-1322-y.
49. Hecker AT, Shea M, Hayhurst JO, Myers ER, Meeks LW, Hayes WC. Pull-out strength of suture anchors for rotator cuff and Bankart lesion repairs. Am J Sports Med 1993;21:874-9.
50. Hernigou P, Flouzat Lachaniette CH, Delambre J, Zilber S, Duffiet P, Chevallier N, et al. Biologic augmentation of rotator cuff repair with mesenchymal stem cells during arthroscopy improves healing and prevents further tears: a case-controlled study. Int Orthop 2014;38:1811-8. https://doi.org/10.1007/s00264-014-2391-1.
51. Hoppe S, Alini M, Benneker LM, Milz S, Boileau P, Zumstein MA. Tenocytes of chronic rotator cuff tendon tears can be stimulated by platelet-released growth factors. J Shoulder Elbow Surg 2013;22:340-9. https://doi.org/10.1016/j.jse.2012.01.016.
52. Iyengar JJ, Porat S, Burnett KR, Marrero-Perez L, Hernandez VH, Nottage WM. Magnetic resonance imaging tendon integrity assessment after arthroscopic partial-thickness rotator cuff repair. Arthroscopy 2011;27:306-13. https://doi.org/10.1016/j.arthro.2010.08.017.
53. Jo CH, Kim JE, Yoon KS, Shin S. Platelet-rich plasma stimulates cell proliferation and enhances matrix gene expression and synthesis in tenocytes from human rotator cuff tendons with degenerative tears. Am J Sports Med 2012;40:1035-45. https://doi.org/10.1177/0363546512437525.
54. Kamath G, Galatz LM, Keener JD, Teefey S, Middleton W, Yamaguchi K. Tendon integrity and functional outcome after arthroscopic repair of high-grade partial-thickness supraspinatus tears. J Bone Joint Surg Am 2009;91:1055-62. https://doi.org/10.2106/JBJS.G.00118.
55. Kartus J, Kartus C, Rostgard-Christensen L, Sernert N, Read J, Perko M. Long-term clinical and ultrasound evaluation after arthroscopic acromioplasty in patients with partial rotator cuff tears. Arthroscopy 2006;22:44-9. https://doi.org/10.1016/j.arthro.2005.07.027.
56. Kieser C. Eugen Bircher—Schweizer Pionier der Arthroskopie (1883–1956). Arthroskopie 2004;17:272-6.
57. Kieser CW, Jackson RW. Severin Nordentoft: The first arthroscopist. Arthroscopy 2001;17:532-5.
58. Kim KC, Shin HD, Lee WY, Han SC. Repair integrity and functional outcome after arthroscopic rotator cuff repair: double-row versus suture-bridge technique. Am J Sports Med 2012;40:294-9. https://doi.org/10.1177/0363546511425657.
59. Kim SJ, Kim SH, Moon HS, Chun YM. Footprint contact area and interface pressure comparison between the knotless and knot-tying transosseous-equivalent technique for rotator cuff repair. Arthroscopy 2016;32:7-12. https://doi.org/10.1016/j.arthro.2015.07.004.
60. Koh KH, Kang KC, Lim TK, Shon MS, Yoo JC. Prospective randomized clinical trial of single- versus double-row suture anchor repair in 2- to 4-cm rotator cuff tears: clinical and magnetic resonance imaging results. Arthroscopy 2011;27:453-62. https://doi.org/10.1016/j.arthro.2010.11.059.
61. Kummer F, Hergan DJ, Thut DC, Pahk B, Jazrawi LM. Suture loosening and its effect on tendon fixation in knotless double-row rotator cuff repairs. Arthroscopy 2011;27:1478-84. https://doi.org/10.1016/j.arthro.2011.06.019.
62. Lapner PL, Sabri E, Rakhra K, McRae S, Leiter J, Bell K, et al. A multicenter randomized controlled trial comparing single-row with double-row fixation in arthroscopic rotator cuff repair. J Bone Joint Surg Am 2012;94:1249-57. https://doi.org/10.2106/JBJS.K.00999.
63. Leek BT, Robertson C, Mahar A, Pedowitz RA. Comparison of mechanical stability in double-row rotator cuff repairs between a knotless transtendon construct versus the addition of medial knots. Arthroscopy 2010;26:S127-33. https://doi.org/10.1016/j.arthro.2010.02.035.
64. Lo IK, Burkhart SS. Arthroscopic repair of massive, contracted, immobile rotator cuff tears using single and double interval slides: technique and preliminary results. Arthroscopy 2004;20:22-33. https://doi.org/10.1016/j.arthro.2003.11.013.
65. Ma CB, Comerford L, Wilson J, Puttlitz CM. Biomechanical evaluation of arthroscopic rotator cuff repairs: double-row compared with single-row fixation. J Bone Joint Surg Am 2006;88:403-10. https://doi.org/10.2106/JBJS.D.02887.
66. Ma HL, Chiang ER, Wu HT, Hung SC, Wang ST, Liu CL, et al. Clinical outcome and imaging of arthroscopic single-row and double-row rotator cuff repair: a prospective randomized trial. Arthroscopy 2012;28:16-24. https://doi.org/10.1016/j.arthro.2011.07.003.
67. MacGillivray JD, Ma CB. An arthroscopic stitch for massive rotator cuff tears: the Mac stitch. Arthroscopy 2004;20:669-71. https://doi.org/10.1016/j.arthro.2004.04.065.
68. Malahias MA, Kostretzis L, Chronopoulos E, Brilakis E, Avramidis G, Antonogiannakis E. Arthroscopic partial repair for massive rotator cuff tears: does it work? A systematic review. Sports Med Open 2019;5:13. https://doi.org/10.1186/s40798-019-0186-z.
69. Mazzocca AD, Bollier MJ, Ciminiello AM, Obopilwe E, DeAngelis JP, Burkhart SS, et al. Biomechanical evaluation of arthroscopic rotator cuff repairs over time. Arthroscopy 2010;26:592-9. https://doi.org/10.1016/j.arthro.2010.02.009.
70. Mazzocca AD, Millett PJ, Guanche CA, Santangelo SA, Arciero RA. Arthroscopic single-row versus double-row suture anchor rotator cuff repair. Am J Sports Med 2005;33:1861-8. https://doi.org/10.1177/0363546505279575.
71. McElvany MD, McGoldrick E, Gee AO, Neradilek MB, Matsen FA 3rd. Rotator cuff repair: published evidence on factors associated with repair integrity and clinical outcome. Am J Sports Med 2015;43:491-500. https://doi.org/10.1177/0363546514529644.
72. Melillo AS, Savoie FH 3rd, Field LD. Massive rotator cuff tears: débridement versus repair. Orthop Clin North Am 1997;28:117-24.
73. Mihata T, Lee TQ, Hasegawa A, Fukunishi K, Kawakami T, Fujisawa Y, et al. Five-Year Follow-up of Arthroscopic Superior Capsule Reconstruction for Irreparable Rotator Cuff Tears. J Bone Joint Surg Am 2019;101:1921-30. https://doi.org/10.2106/JBJS.19.00135.
74. Mihata T, McGarry MH, Pirolo JM, Kinoshita M, Lee TQ. Superior capsule reconstruction to restore superior stability in irreparable rotator cuff tears: a biomechanical cadaveric study. Am J Sports Med 2012;40:2248-55. https://doi.org/10.1177/0363546512456195.
75. Monro A. A description of all the bursae mucosae of the human body. Edinburgh: Elliot C, and Kay T & Co; 1788.
76. Neviaser JS, Neviaser RJ, Neviaser TJ. The repair of chronic massive ruptures of the rotator cuff of the shoulder by use of a freeze-dried rotator cuff. J Bone Joint Surg Am 1978;60:681-4.
77. Ostrander RV 3rd, McKinney BI. Evaluation of footprint contact area and pressure using a triple-row modification of the suture-bridge technique for rotator cuff repair. J Shoulder Elbow Surg 2012;21:1406-12. https://doi.org/10.1016/j.jse.2011.10.027.
78. Park JY, Lhee SH, Choi JH, Park HK, Yu JW, Seo JB. Comparison of the clinical outcomes of single- and double-row repairs in rotator cuff tears. Am J Sports Med 2008;36:1310-6. https://doi.org/10.1177/0363546508315039.
79. Park MC, McGarry MH, Gunzenhauser RC, Benefiel MK, Park CJ, Lee TQ. Does transosseous-equivalent rotator cuff repair biomechanically provide a "self-reinforcement" effect compared with single-row repair? J Shoulder Elbow Surg 2014;23:1813-21. https://doi.org/10.1016/j.jse.2014.03.008.
80. Park SG, Shim BJ, Seok HG. How much will high tension adversely affect rotator cuff repair integrity? Arthroscopy 2019;35:2992-3000. https://doi.org/10.1016/j.arthro.2019.05.049.
81. Pennington WT, Bartz BA, Pauli JM, Walker CE, Schmidt W. Arthroscopic superior capsular reconstruction with acellular dermal allograft for the treatment of massive irreparable rotator cuff tears: short-term clinical outcomes and the radiographic parameter of superior capsular distance. Arthroscopy 2018;34:1764-73. https://doi.org/10.1016/j.arthro.2018.01.009.
82. Perthes G. Über Operationen bei habitueller Schulterluxation. Deutsche Zeitschrift f Chirurgie 1906;85:199-227.
83. Peters KS, Lam PH, Murrell GA. Repair of partial-thickness rotator cuff tears: a biomechanical analysis of footprint contact pressure and strength in an ovine model. Arthroscopy 2010;26:877-84. https://doi.org/10.1016/j.arthro.2010.04.007.
84. Plachel F, Siegert P, Ruttershoff K, Thiele K, Akgun D, Moroder P, et al. Long-term results of arthroscopic rotator cuff repair: a follow-up study comparing single-row versus double-row fixation techniques. Am J Sports Med 2020;48:1568-74. https://doi.org/10.1177/0363546520919120.
85. Ponce BA, Hosemann CD, Raghava P, Tate JP, Eberhardt AW, Lafosse L. Biomechanical evaluation of 3 arthroscopic self-cinching stitches for shoulder arthroscopy: the lasso-loop, lasso-mattress, and double-cinch stitches. Am J Sports Med 2011;39:188-94. https://doi.org/10.1177/0363546510383394.
86. Reed SC, Glossop N, Ogilvie-Harris DJ. Full-thickness rotator cuff tears. A biomechanical comparison of suture versus bone anchor techniques. Am J Sports Med 1996;24:46-8.
87. Rockwood CA Jr, Williams GR Jr, Burkhead WZ Jr. Débridement of degenerative, irreparable lesions of the rotator cuff. J Bone Joint Surg Am 1995;77:857-66.
88. Ryu KJ, Kim BH, Lee Y, Lee YS, Kim JH. Modified suture-bridge technique to prevent a marginal dog-ear deformity improves structural integrity after rotator cuff repair. Am J Sports Med 2015;43:597-605. https://doi.org/10.1177/0363546514562175.
89. Sahoo S, Ouyang H, Goh JC, Tay TE, Toh SL. Characterization of a novel polymeric scaffold for potential application in tendon/ligament tissue engineering. Tissue Eng 2006;12:91-9. https://doi.org/10.1089/ten.2006.12.91.
90. Saino E, Focarete ML, Gualandi C, Emanuele E, Cornaglia AI, Imbriani M, et al. Effect of electrospun fiber diameter and alignment on macrophage activation and secretion of proinflammatory cytokines and chemokines. Biomacromolecules 2011;12:1900-11. https://doi.org/10.1021/bm200248h.
91. Salata MJ, Sherman SL, Lin EC, Sershon RA, Gupta A, Shewman E, et al. Biomechanical evaluation of transosseous rotator cuff repair: do anchors really matter? Am J Sports Med 2013;41:283-90. https://doi.org/10.1177/0363546512469092.
92. Schlegel TF, Abrams JS, Bushnell BD, Brock JL, Ho CP. Radiologic and clinical evaluation of a bioabsorbable collagen implant to treat partial-thickness tears:

a prospective multicenter study. J Shoulder Elbow Surg 2018;27:242-51. https://doi.org/10.1016/j.jse.2017.08.023.

93. Schlegel TF, Hawkins RJ, Lewis CW, Turner AS. An in vivo comparison of the modified Mason-Allen suture technique versus an inclined horizontal mattress suture technique with regard to tendon-to-bone healing: a biomechanical and histologic study in sheep. J Shoulder Elbow Surg 2007;16:115-21. https://doi.org/10.1016/j.jse.2006.05.002.
94. Shin SJ. A comparison of 2 repair techniques for partial-thickness articular-sided rotator cuff tears. Arthroscopy 2012;28:25-33. https://doi.org/10.1016/j.arthro.2011.07.005.
95. Sileo MJ, Ruotolo CR, Nelson CO, Serra-Hsu F, Panchal AP. A biomechanical comparison of the modified Mason-Allen stitch and massive cuff stitch in vitro. Arthroscopy 2007;23:235-240.e1-2. https://doi.org/10.1016/j.arthro.2006.11.007.
96. Snyder SJ. Arthroscopic fixation of rotator cuff tears: a preliminary report. In: 12th Annual meeting of the Arthroscopy Association of North America. Palm Desert, CA; 1993.
97. Snyder SJ, Pachelli AF, Del Pizzo W, Friedman MJ, Ferkel RD, Pattee G. Partial thickness rotator cuff tears: results of arthroscopic treatment. Arthroscopy 1991;7:1-7.
98. Strauss EJ, Salata MJ, Kercher J, Barker JU, McGill K, Bach BR Jr, et al. Multimedia article. The arthroscopic management of partial-thickness rotator cuff tears: a systematic review of the literature. Arthroscopy 2011;27:568-80. https://doi.org/10.1016/j.arthro.2010.09.019.
99. Takagi K. The classic. Arthroscope. Kenji Takagi. J. Jap. Orthop. Assoc., 1939. Clin Orthop Relat Res 1982:6-8.
100. Tauro JC. Arthroscopic “interval slide” in the repair of large rotator cuff tears. Arthroscopy 1999;15:527-30.
101. Tauro JC. Arthroscopic repair of large rotator cuff tears using the interval slide technique. Arthroscopy 2004;20:13-21. https://doi.org/10.1016/j.arthro.2003.10.013.
102. Visscher LE, Jeffery C, Gilmour T, Anderson L, Couzens G. The history of suture anchors in orthopaedic surgery. Clin Biomech 2019;61:70-8. https://doi.org/10.1016/j.clinbiomech.2018.11.008.
103. Walch G, Nove-Josserand L, Levigne C, Renaud E. Tears of the supraspinatus tendon associated with "hidden" lesions of the rotator interval. J Shoulder Elbow Surg 1994;3:353-60.
104. Weber SC. Arthroscopic débridement and acromioplasty versus mini-open repair in the treatment of significant partial-thickness rotator cuff tears. Arthroscopy 1999;15:126-31.
105. Wlk MV, Abdelkafy A, Hexel M, Krasny C, Aigner N, Meizer R, et al. Biomechanical evaluation of suture-tendon interface and tissue holding of three suture configurations in torn and degenerated versus intact human rotator cuffs. Knee Surg Sports Traumatol Arthrosc 2015;23:386-92. https://doi.org/10.1007/s00167-014-2988-3.
106. Yamamoto N, Itoi E, Tuoheti Y, Seki N, Abe H, Minagawa H, et al. Glenohumeral joint motion after medial shift of the attachment site of the supraspinatus tendon: a cadaveric study. J Shoulder Elbow Surg 2007;16:373-8. https://doi.org/10.1016/j.jse.2006.06.016.