Technical Note

A Modified Mason-Allen Suture Enhancement Technique (Sunglasses Loop) for Single-Row Repair of Medium-to-Large Rotator Cuffs

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Abstract: We propose a single-row repair method for medium-to-large rotator cuff rotator cuff tears using a modified Mason-Allen suture enhancement technique (sunglasses loop), which uses high-tensile modified Mason-Allen sutures to close the medial rotator cuff tissues to form a sunglasses loop, resets the rotator cuff tissues via traction with the high-tensile suture, repairs the rotator cuff in a single row with triple-loaded suture anchor (anchor with 3 high-strength sutures), and finally employs an outer row of staples to secure the suture to the lateral aspect of the greater tuberosity, preventing the tendon from pulling out. This method uses a special sunglasses-shaped suture loop, which produces an increase in holding power and a reduction in tension relative to other single-row repair techniques and reduces the rate of rotator cuff retear.

As shoulder arthroscopic diagnosis and treatment technology continue to progress and mature, an increasing number of torn rotator cuffs are repaired arthroscopically. In recent years, the continuous research in and development of arthroscopy-related materials has resulted in great progress in arthroscopic rotator cuff repair, itself achieving beneficial therapeutic effects.[1] However, as the result of joint and injured tendon tissue degeneration and bone volume reductions in the footprint area, an important challenge for large rotator cuff tears in elderly individuals is their tendency to retear after repair.[2]

The application of the classic double-row suture bridge technique has seen increased used in very large rotator cuff tear repairs,[3] whereas the classic suture bridge technique, in which an internal row of nails is mainly used in a horizontal mattress suture, has achieved good results in most patients. However, several recent studies have shown that even with this type of suture, the injury is prone to retear at the medial tendon-muscle belly junction, suggesting that knotting of the suture when cutting the tendon blocks the blood supply to the tendon and that the overconcentration of stress accelerates tendon degeneration and necrosis.[4] Various improved suture methods have been reported in the literature to address this problem, but these methods often require complex surgical techniques and more anchors, which undoubtedly disadvantages novice surgeons and increases the economic burden for the patient. Thus, we propose an improved medial knotless suture-enhanced single-row repair method, the key aspect of which uses a modified Mason-Allen suture to close the medial rotator cuff tissue, forming a suture loop that provides resistance and reduces tension, which we have named the sunglasses loop because the final appearance of the sutures in the rotator cuff after stitching is similar to a pair of sunglasses.

Surgical Technique

The patient is placed in the lateral position under general anesthesia. The affected upper limb is fixed in traction at 45° abduction and 20° forward flexion. A posterior approach is established 2 cm below and 1 cm medial to the posterior lateral angle of the acromion, and an arthroscope is inserted to evaluate the

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glenohumeral joint and the subacromial space, to observe the anatomical structures and bursal hyperplasia, as well as to assess whether there is any injury to the long head tendon of the biceps and the degree of acromial hyperplasia and rotator cuff tear (Fig 1). Anterior, anterolateral, and lateral approaches are established, and subacromial bursa cleaning and acromioplasty are performed sequentially. The damaged tendon segments and surrounding tissues are extensively loosened and trimmed, the tension of the damaged tendon is tested, and the position of the implantation of the anchors is marked.

The arthroscope is placed posterolaterally as an observation approach, and the rotator cuff tissue is lifted perpendicular to the direction of the suture passer (EXPRESSEW; DePuy Mitek) via an anterolateral approach tissue grasper. A polymer polyethylene hybrid suture (ORTHOCORD SUTURE; DePuy Mitek, Warsaw, IN) is used to pass the suture through a suture passer (EXPRESSEW; DePuy Mitek) suture shuttle technique. In the first step, the suture passer is threaded through one end of the suture via an anterior approach from the articular side to the bursal side, and the suture is recovered by the anterolateral approach grasper, with the point of passage through the tendon as far inward as possible, ideally 10 to 12 mm medial to the outer edge of the rotator cuff tear, to maintain compression on the lateral rotator cuff tendon (Fig 2A, Video 1). The other end of the second part of the suture is passed through the rotator cuff tissue 1 cm from the exit of the first stitch and passed through in the bursal-articular direction, creating a thread loop on the bursal side of the rotator cuff and recovering the articular side of the suture through the anterior-lateral approach (Fig 2B, Video 1). In the third step, the suture end passes medial to the exit of the second stitch of the thread loop on the

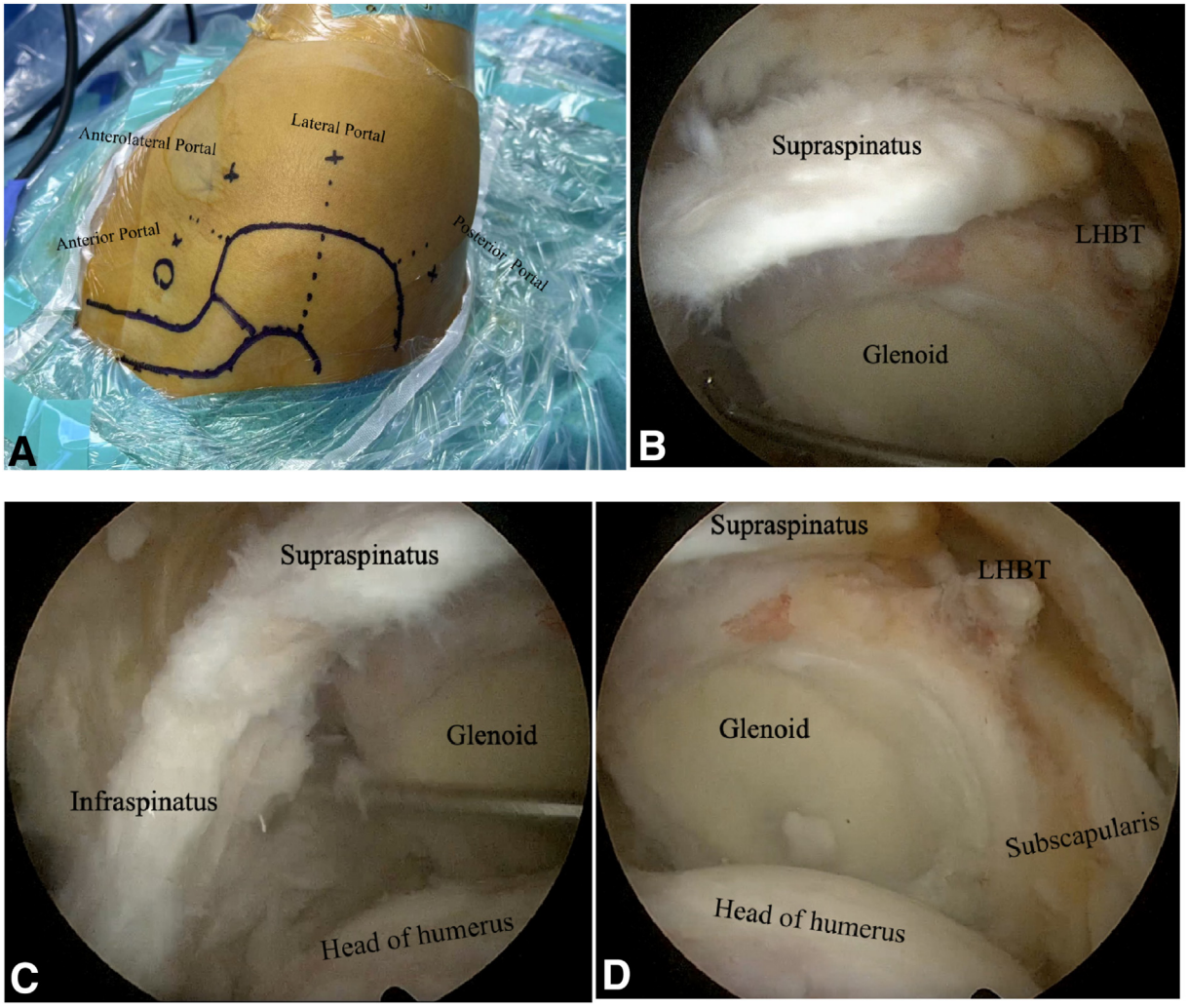

Fig 1. Assess whether there is any injury to the long head tendon of the biceps and the degree of acromial hyperplasia and rotator cuff tear. (A) Location of arthroscopic portals (right shoulder). (B-D) The patient's right shoulder is positioned in the lateral decubitus position and viewed through a lateral portal. The torn and reclined supraspinatus tendon and infraspinatus are healthy, the subscapularis is fine, but the long head of the biceps tendon has been ruptured.

bursal side of the rotator cuff and then through the joint-bursal side (Fig 3A, Video 1); similarly, the other end of the suture passes medial to the exit of the first stitch of the thread loop on the joint-bursal side, completing the modified Mason-Allen suture to form a sunglasses loop (Fig 3B, Video 1).

At this point, a single-row anchor (4.5-mm HEALIX ADVANCE BR Anchor; DePuy Mitek, Raynham, MA) with 3 high-strength sutures is placed into the greater tuberosity, and the assistant maintains traction on the previously completed suture to complete a simple vertical mattress suture repair of the rotator cuff (Fig 4A, Video 1). If the tear is extensive, the number of sunglasses loop sutures for medial repair may be increased depending on the specific repair. All medial sutures are then recovered through an anterolateral approach and secured with lateral-row anchor (5.5-mm HEALIX ADVANCE Knotless BR Anchor; DePuy Mitek) 10 mm distal to the greater tuberosity (Fig 4B, Video 1).

The modified Mason-Allen suture enhancement (sunglasses loop) single-row repair is a knotless, rapid repair that consists of a medial knotless sunglasses suture loop and a lateral, triple-loaded suture anchor stitch single-row repair, in which the medial sunglasses loop suture enhances the suture grip and reduces the number of cuts in the tendon tissue, and the force of traction acts

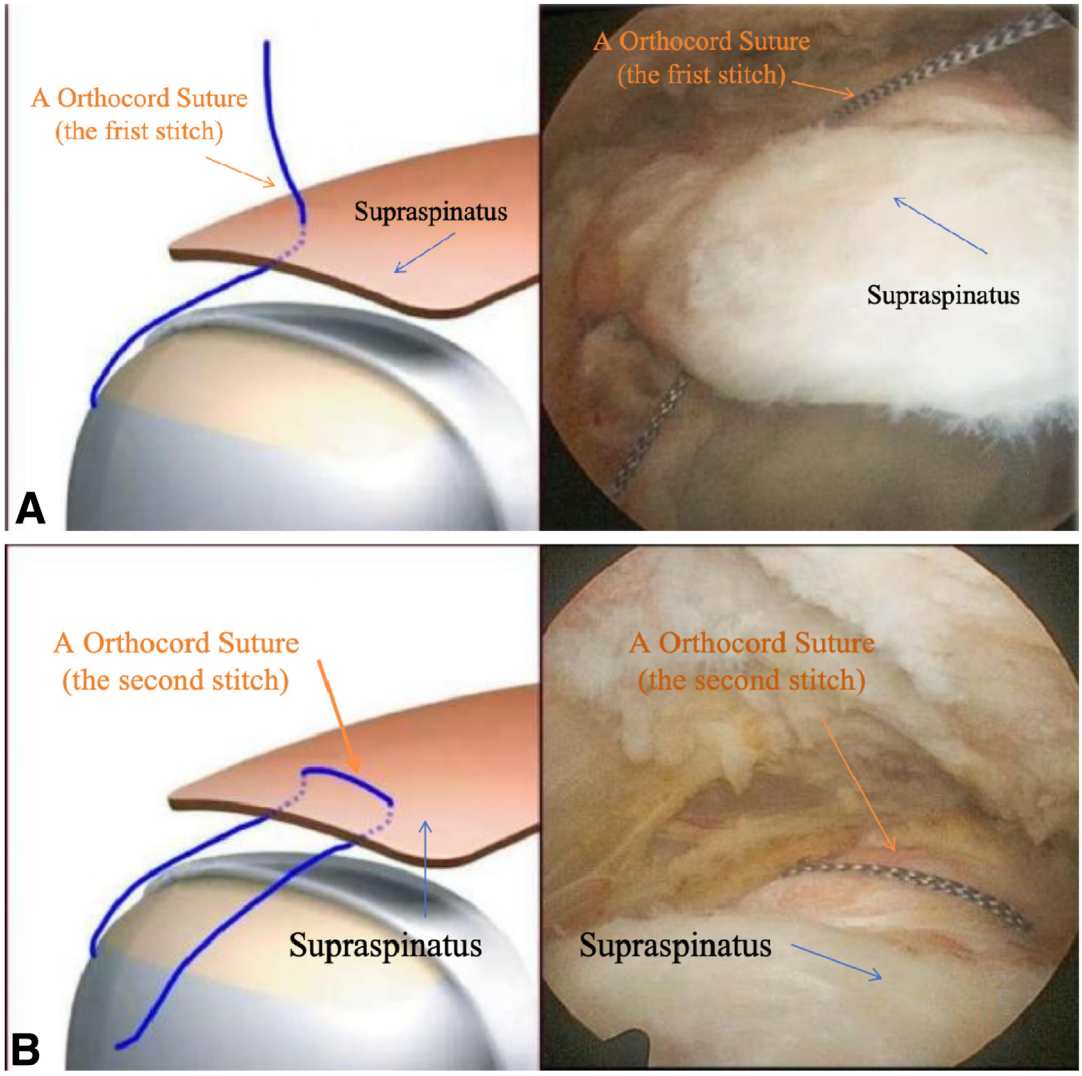

Fig 2. (A) Illustration and arthroscopic image of first tendon passage of the Mason-Allen (sunglasses loop) technique. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the lateral decubitus position while an ORTHOCORD Suture (DePuy) is first passed through the articular-side to the bursal-side using a suture passer (EXPRESSEW; DePuy Mitek) shuttling device. (B) Illustration and arthroscopic image of the second tendon passage tendon passage of Mason-Allen (sunglasses loop) technique. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the lateral decubitus position as the other end of the suture is passed through the rotator cuff tissue 1 cm from the exit of the first stitch, and the bursa-articular direction is passed through, creating a thread loop on the bursa side of the rotator cuff.

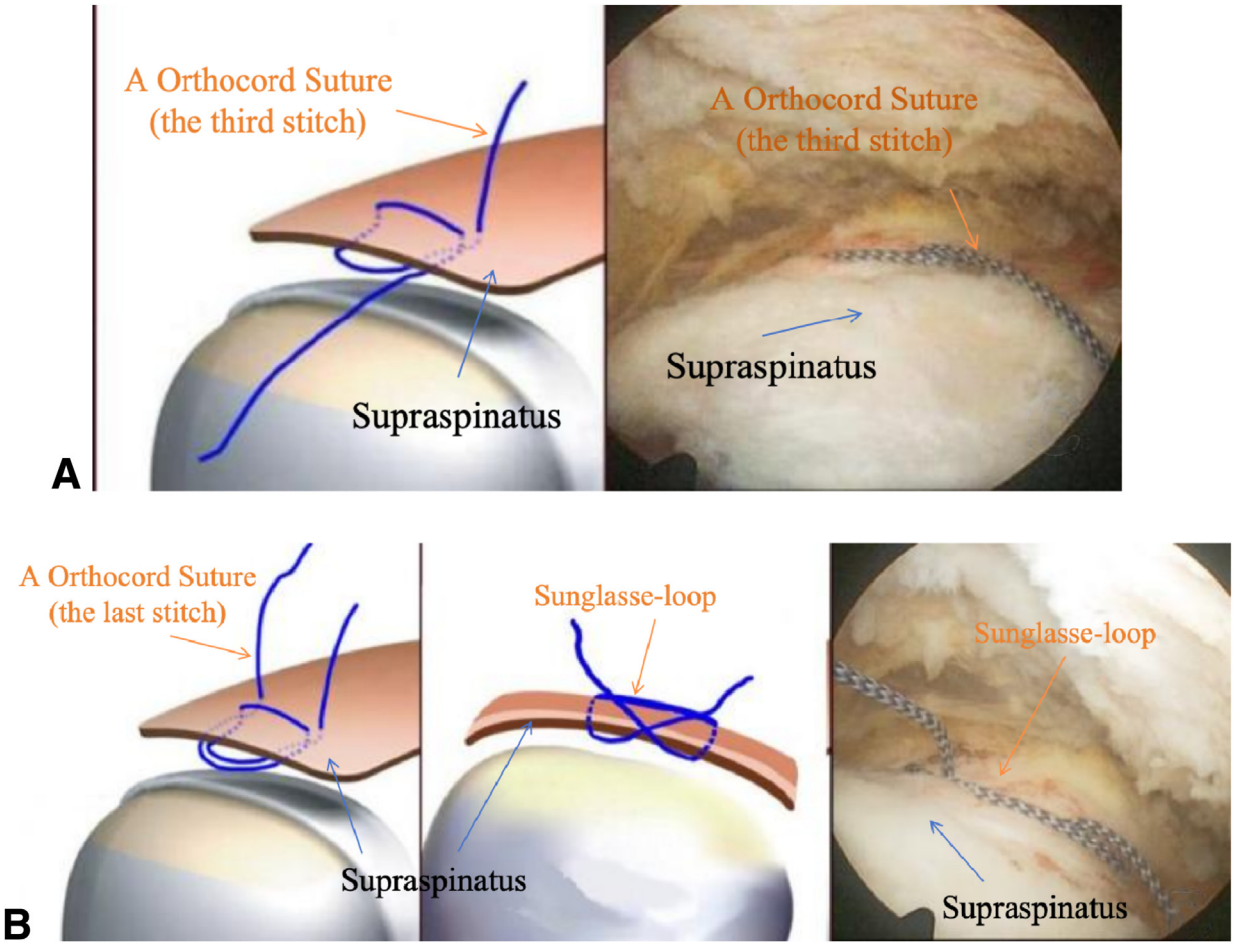

Fig 3. (A) Illustration and arthroscopic image of the third tendon passage of the Mason-Allen (sunglasses loop) technique. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the lateral decubitus position as the suture end passes medial to the second stitch exit of the thread loop on the bursa side of the rotator cuff and passes through on the joint-bursa side. (B) Illustration and arthroscopic image of the fourth tendon passage of the Mason-Allen (sunglasses loop) technique. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the lateral decubitus position as the other end of the suture passes medial to the first stitch exit of the thread loop on the joint-bursa side, completing the modified Mason-Allen suture to form the sunglasses loop, which acts as a rip-stop.

as a decompression force on the single-row repair anchor suture, thus avoiding retears and increasing the rate of healing. Furthermore, 1-, 3-, 6-, and 12-month postoperative magnetic resonance imaging demonstrated regeneration in the footprint, indicating a good trend in tendon-to-bone healing (Fig 5).

Discussion

Elderly patients with rotator cuff repair have problems such as tissue degeneration at the torn ends and loss of bone mass in the footprint area, which often leads to difficulties in healing and retearing after repair. With improvements and developments in arthroscopic techniques and concepts, an increasing number of methods have been used to solve this problem, especially the understanding of the rotator cuff humeral tuberosity footprint area. Repair focusing on the reconstruction of the rotator cuff footprint area coverage of the concept has been proposed,[5] and double-row suture bridge technology has gradually become the gold standard for rotator cuff repair.

For rotator cuff tears smaller than 3 cm, the single-row anchor repair technique does not produce significantly different effects from the double-row anchor repair technique. However, in the repair of medium and large tears, single-row repair has insufficient tissue-holding power, and when the lateral tissue quality is poor, the rotator cuff is more likely to retear. In standard suture bridge repair, the medial tendon is sutured horizontally with the anchor line first, which tends to result in greater tissue quality,[6] increasing the holding force and fixation strength and reducing the risk of lateral tendon tear.

However, additional studies revealed that the horizontal mattress suture still produced a strong tissue-cutting force, necessitating the development of a large

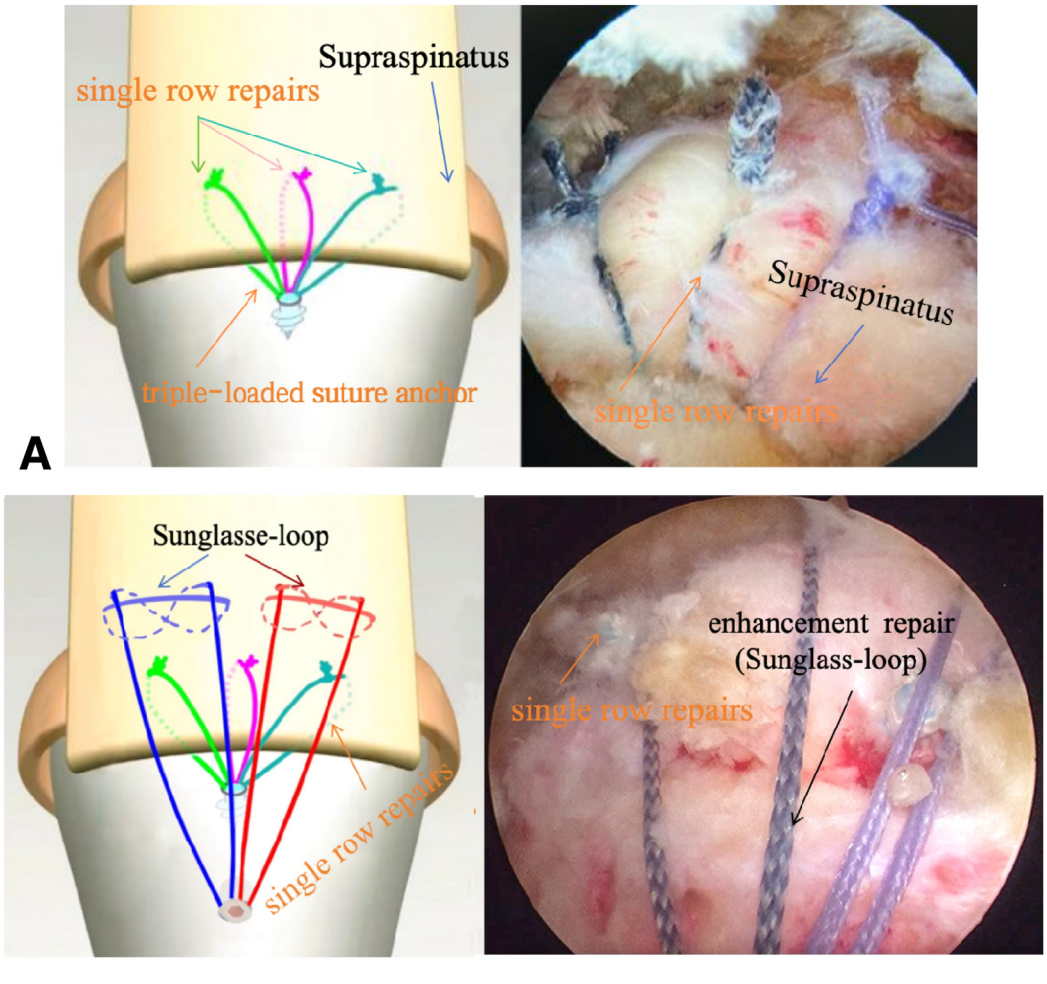

Fig 4. (A) Illustration and arthroscopic image of the single row with triple-loaded suture anchor. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in lateral decubitus position. (B) Final configuration of a Mason-Allen Suture enhancement technique (sunglasses loop) repair. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the lateral decubitus position.

number of improved suture techniques, which have been reported and applied in clinical practice and aim to improve the simple horizontal mattress suture on the medial side of the suture bridge to reduce the rate of tearing. The Mason-Allen suture was first applied in open rotator cuff repair surgery by Gerber et al.,[7] who achieved favorable clinical outcomes and demonstrated improved tensile strength in relevant biomechanical tests, reducing the incidence of aseptic necrosis of the tendon and promoting long-term tendon-bone healing. The Mason-Allen suture technique requires skilled surgical techniques, and even some experienced doctors who try to attempt this method under the microscope find it difficult, whereas the authors of some other studies using Mason-Allen single-row repairs have found that its biomechanical properties are almost the same as those of ordinary double-row repairs, but the latter results in a better tendon-bone contact area.[8]

Mazzocca et al.[9] reported that the medial mattress suture tended to fail before the lateral suture during increased loading after double-row repairs, suggesting that the medial tendon was under more tension. In the study by Cho et al.,[10] the rate of retearing after conventional suture bridge repair was unexpectedly high, which was attributed to failure of the medial suture repair, probably attributable to the narrowing of the rotator cuff tendon by the medial decubitus suture, which affected the hemodynamics of the tendon and led to tendon necrosis. To reduce the possibility of strangulation and relatively rapid necrosis of the medial row of rotator cuff tendons, the method for fixing the knots of the medial row and adjusting the tension may be a worthy consideration, and therefore many researchers have simplified and improved this technique in different ways based on the Mason-Allen suture principle, which is easy to perform.

We offer a modified Mason-Allen suture enhancement technique (sunglasses loop) for the single-row repair of medium-to-large rotator cuff tears. The difference between this method and the traditional

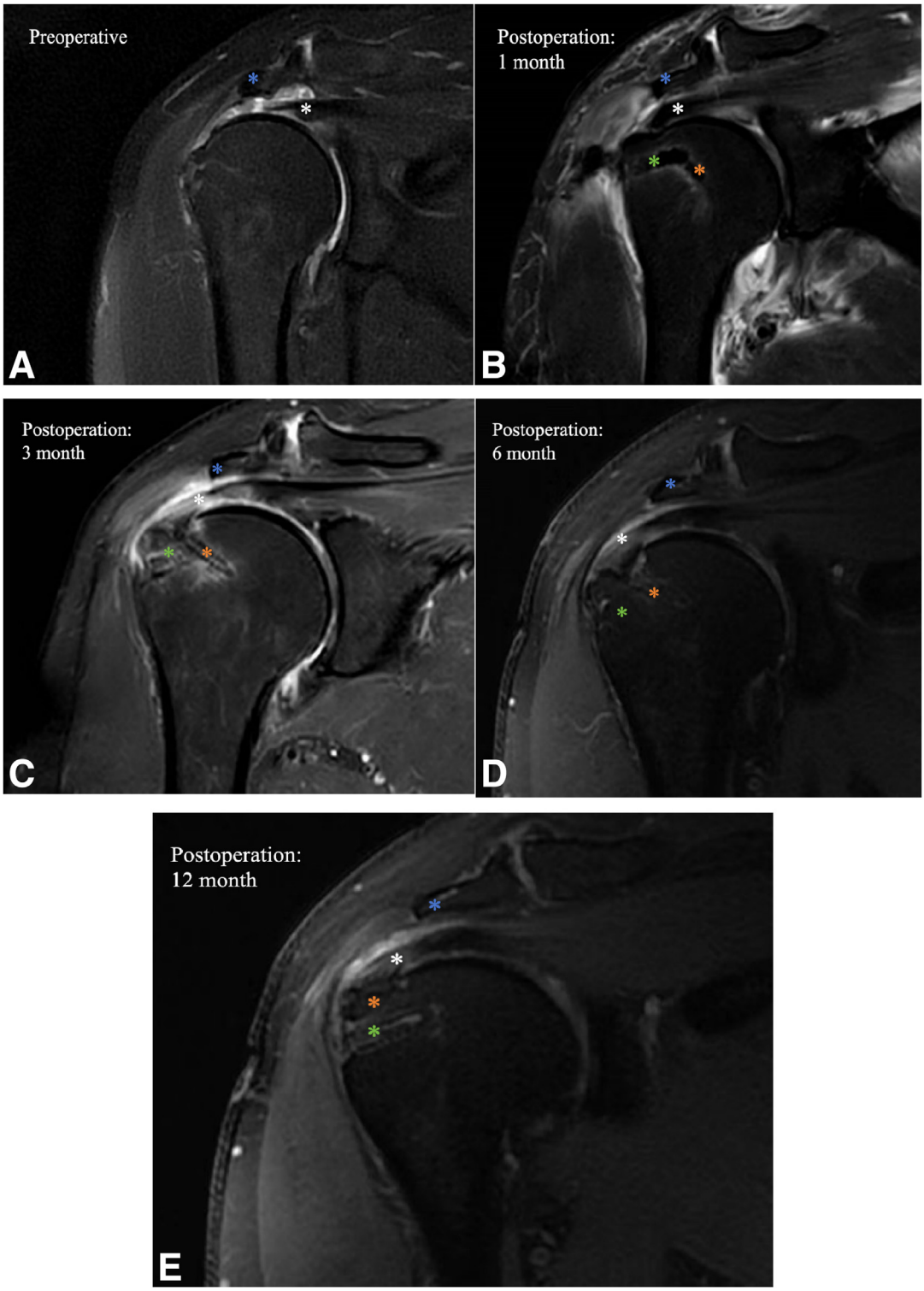

Fig 5. (A) Preoperative T2-weighted coronal MRI. (B-E) 1, 3, 6, and 12 months' postoperative T2-weighted coronal MRI. White asterisk: supraspinatus; blue asterisk: Acromion; orange asterisk: triple-loaded suture anchor (HEALIX ADVANCE BR Anchor; DePuy Mitek); and green asterisk: lateral-row anchor (HEALIX ADVANCE Knotless BR Anchor; DePuy Mitek). (MRI, magnetic resonance imaging.)

suture bridge with a medial mattress suture followed by knotting is that this method uses only a high-strength modified Mason-Allen suture to close the medial rotator cuff tissue to form a sunglasses-shaped suture loop, which maintains maximum resetting of the rotator cuff under the pull of the high-strength

Table 1. Advantages and Disadvantages of the Sunglasses Loop

Advantages	Disadvantages
• Has superb holding power on the rotator cuff tissue • Medial knotless suture maintains blood supply to the medial tendon and reduces the ability of the suture to cut into, irritate, and impinge • Sunglasses loop reduces the tension of the simple suture in the lateral footprint area and the tension of tendon retearing during free limb of postoperative rehabilitation activities • Reduces the need for medial anchors and the medical economic burden of patients • The sunglasses loop is an antitear structure that prevents tendon rupture • The technique provides a sufficient tendon-bone contact area to achieve better blood flow to the tendon.	• Biomechanical properties have not been thoroughly investigated for this technique. • increased stress concentration in the lateral row anchors can increase the risk of anchor failure risk of anchor failure. • Sunglasses loop suture technique may be more complex and could increase surgical time and make the procedure more technically challenging

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
• Panoramic view of the rotator cuff tear obtained through the lateral subacromial portal • Complete anterolateral full release of the deep deltoid fascia to increase the workspace under the subacromial • Extensive and complete release of the rotator cuff tissue with severe retraction is required • Ensure appropriate width between each sunglasses loop suture on the tear margins of the tendon • The second part of the seam requires polydioxanone suture traction through the threads with a suture passer • Use of anterior and anterolateral working portals will aid in suture management • If the tear is extensive, the number of sunglasses loop sutures for medial repair may be increased depending on the specific repair; the same goes for the triple-loaded suture anchor • The position of the triple-loaded suture anchor placement can be moved forward to reduce tissue tension	• Failure to perform this release compromises visibility for suture management and placement of lateral-row anchors • Poor placement of lateral-row anchor may result in excessive tension at the repair site • Failure to manage sunglasses loop sutures can lead to technical errors and additional operating time • Proficiency in this technology may require a learning curve

suture after suture closure, and a single row of anchors, triple loaded with a high-strength suture, if the tear is extensive, the number of the triple-loaded suture anchor may be increased for simply repair the lateral rotator cuff to the footprint area. The lateral rotator cuff is repaired to the footprint area with a simple triple line of anchors, and the sutures are fixed to the lateral aspect of the greater tuberosity with the lateral-row anchor We believe that the benefits of this method can be summarized as follows: (1) The sunglasses loop has superb holding power on the rotator cuff tissue. (2) The medial simple suture knotless technique reduces the degree to which the suture cuts into, irritates, and impinges on the tendon and reduces the possibility of tendon necrosis. (3) The sunglasses loop reduces the tension of the simple suture in the lateral footprint area and increases the healing rate. (4) The technique provides a sufficient tendon-bone contact area to achieve better blood flow to the tendon (Tables 1 and 2).

Although its biomechanical properties have not been thoroughly investigated, our clinical use of Mason-Allen suture-enhanced (sunglasses loop) single-row repairs for rotator cuff tears resulted in strong fixation in the inner row area and good mesh interconnections throughout the rotator cuff. We advocate the use of this technique for medium-to-large rotator cuff tears with relatively poor tissue quality to increase tissue retention and decrease tear rates.

Disclosures

All authors (J.O., X.X., B.L., L.Z., Y.X., Y.Q., T.J., and K.Y.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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