OPERATIVE TECHNIQUE

Arthroscopic Intra-Articular Repair of the Torn Subscapularis Tendon with Single Anterior Portal, Single Suture Anchor, and X-Shaped Fixation Technique

Yi-Lin Xiong, MD[1], Wei-Jie Liu, BMed[1], Chao Su, BMed[1], Shi-Da Kuang, BMed[1], Yu-Sheng Li, MD[1], Yu-Mei Wu, BMed[1], Shu-Guang Gao, MD[1,2,3,4]

[1]Department of Orthopaedics, Xiangya Hospital, Central South University, [2]Hunan Key Laboratory of Joint Degeneration and Injury, [3]Hunan Engineering Research Center of Osteoarthritis and [4]National Clinical Research Center of Geriatric Disorders, Xiangya Hospital, Central South University, Changsha, Hunan, China

Abstract

Subscapular tendon plays an important role in shoulder joint function. With the advance of magnetic resonance imaging technology and the popularization of arthroscopic shoulder surgery, subscapularis tears have been increasingly detected. However, reduction and fixation of subscapular tendon tears appears to be technically challenging. This study aims to describe an arthroscopic intra-articular X-shaped fixation technique: a procedure of subscapularis tendon repair performed with the aid of a suture passer using only a single anterior portal and a single suture anchor. By incorporating the advantages of a single anterior working portal for anchor placement and tear repair, this technique provides an easier way to use suture lasso and make knots in a limited working space, and the whole procedure is minimally invasive with a short learning curve. This technique has been applied in patients with subscapularis tears involving no intraoperative or postoperative complications. Our technology offers a valuable new treatment option for subscapularis tears.

Key words: arthroscopy; fixation; repair; subscapularis tendon

Introduction

Subscapularis, the strongest and largest tendon of the rotator cuff, acts as an anterior stabilizer of the glenohumeral joint and plays an essential role in the function of the shoulder joint[1]. The incidence of subscapularis tear combined with any of other rotator cuff tears is around 19%–49% among all rotator cuff lesions[2–4]; whereas, the isolated subscapularis tear is less common, with a incidence of 4%[5]. Surgical repair of the subscapularis tendon has the potential for restoring the internal rotation and dynamic anterior glenohumeral stability, as well as the force coupling in the transverse plane[6–8]. However, due to historically neglected attention, subscapularis has been known as the forgotten rotator cuff tendon despite its importance[9]. Fortunately, with advances in techniques over the past two decades, the arthroscopic repair of subscapularis tear has been increasingly popularized and has achieved good clinical results compared to open surgeries[10,11].

Several classifications of subscapularis tears have been described[12–14], among which the classification system proposed by Lafosse is most widely accepted[13]. Lafosse type 1 tears refer to partial tears localized to the superior third of the subscapularis tendon. Type 2 tears refer to complete tears that are confined to the superior third of the tendon. Type

Address for correspondence Shu-Guang Gao, MD< Department of Orthopaedics, Xiangya Hospital, Central South University, No. 87 Xiangya Road, Changsha, Hunan, China 410008 Tel: +8613875980341; Fax: 0731-84327332; Email: 251469675@qq.com

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3 tears refer to complete tears of the superior two-thirds of the tendon. Type 4/5 tears refer to complete ruptures of the entire tendon with or without anterior eccentricity of the humeral head. By now, a number of techniques aiming at arthroscopic subscapularis tendon repair have been described[11,15,16], but most of them are technically challenging and time-consuming. For example, multiple working portals are often required, and the suture management can be cumbersome. In addition, arthroscopic operations are usually hindered by limited visibility and working space.

Thus, in this paper, an arthroscopic procedure for subscapularis tendon repair is described based on an X-shaped fixation technique. Specifically, the repair is performed with the aid of a suture passer using only a single anterior portal and a single suture anchor. By incorporating the advantages of a single anterior working portal for anchor placement and subscapularis tendon repair, this technique provides an easier way to use suture lasso and make knots in the limited working space under a familiar viewing, and the whole procedure is minimally invasive with a short learning curve. This technique is suitable for partial subscapularis tendon lesions (Lafosse type 1–3), and for complete tears of the subscapularis tendon (Lafosse type 4–5), more suture anchors may be needed for a robust fixation. The purpose of the present study is, therefore, to: (i) implement a novel arthroscopic procedure of subscapularis tendon repair; (ii) investigate its clinical results; and (iii) discuss its outcome on the basis of the existing literature.

Surgical Technique

Criteria

The patient inclusion criteria for this study are: (i) patients suffering symptomatic (painful shoulder or impaired shoulder internal rotation) or arthroscopically confirmed tears of the subscapularis tendon (Lafosse types 1–3) with or without other rotator cuff tendon lesions; (ii) patients who underwent shoulder arthroscopic surgery in our institution from June 2019 to June 2020; (iii) patients aged between 35 and 70 years. In addition, the exclusion criteria for this study are: (i) concomitant shoulder fractures, dislocation, or infection; (ii) previous surgery on the affected shoulder; (iii) advanced osteoarthritis of the glenohumeral joint; (iv) neurovascular injury.

Operation Procedure

Patient Setting and Diagnostic Arthroscopy

After appropriate anesthetization, the patient was placed in a beach-chair position with an assistant holding the arm in a desired position. All the bony landmarks were marked, and the operation site was draped after sterilization.

The posterior portal was created through the soft spot of the shoulder. A diagnostic arthroscopy was then performed using a 30° arthroscope by viewing from the posterior portal. Under direct visualization, a spinal needle was used to help establish the anterior portal, and a radiofrequency device was introduced through the anterior portal to open the rotator interval. The shoulder was then elevated slightly and rotated internally to help improve the visualization of the subscapularis and its footprint. Upon confirmation of the subscapularis tendon tear (Figure 1A), its configuration and quality were assessed accordingly. In addition, the long head of the biceps tendon was also evaluated. In case of any pathology of this tendon, tenotomy or tenodesis was performed. The whole procedure was performed with a 30° arthroscope in this study; however, a 70° arthroscope would be able to provide a better visualization, if available.

Tissue Release and Bone Bed Preparation

Once the decision was made to repair the subscapularis tendon tear, the torn edge would be shaved to remove poor-quality tissues and enhance the healing capacity after repair. The middle glenohumeral ligament, which obstructs the view of the subscapularis tendon, was usually incised for visualization. A grasper could be used to assess the tension on the subscapularis. For larger and retracted tears, the coracohumeral ligament and adhesions to the anterosuperior margins of the subscapularis tendon would be released to facilitate better mobilization. The bone bed of the footprint on the lesser tuberosity was then prepared using the radiofrequency device and motorized burr (Figure 1B), and debrided to healthy bleeding bone to enable healing.

Subscapularis Tendon Repair

Only a single suture anchor (5.0 mm TwinFix Ti, Smith & Nephew or 4.5 mm TwinFix Ultra PK, Smith & Nephew) was used for the subscapularis tear repair. An awl was firstly introduced into the joint to create a tunnel for inserting the suture anchor. Thereafter, the double-loaded suture anchor was placed at the upper third of the subscapularis footprint on the lesser tuberosity through the anterior portal (Figure 1C).

After the anchor being inserted, a suture lasso (Arthrex) preloaded with polydioxanone (PDS) was introduced through the anterior working portal for suturing. Depending on the operation site, a left-angled one would be used for a left shoulder and a right-angled one for a right shoulder. To create a vertical loop, the suture lasso penetrated the full thickness of the subscapularis tendon from the bursal side toward the articular side 1–2 mm below the superior margin of the tear and 5–10 mm medial to the lateral margin of the tear (Figure 1D). To use only one anterior portal, preloaded PDS was passed into the joint. When abundant PDS was passed into the joint, the suture lasso was slowly withdrawn from the portal, with additional PDS advanced. This left curved PDS in the joint, and the PDS was then used to relay one limb of the suture thread with the help of the suture grasper. The same step was repeated again to shuttle the other limb of the same suture thread, approximately 5–10 mm inferior to the first stitch.

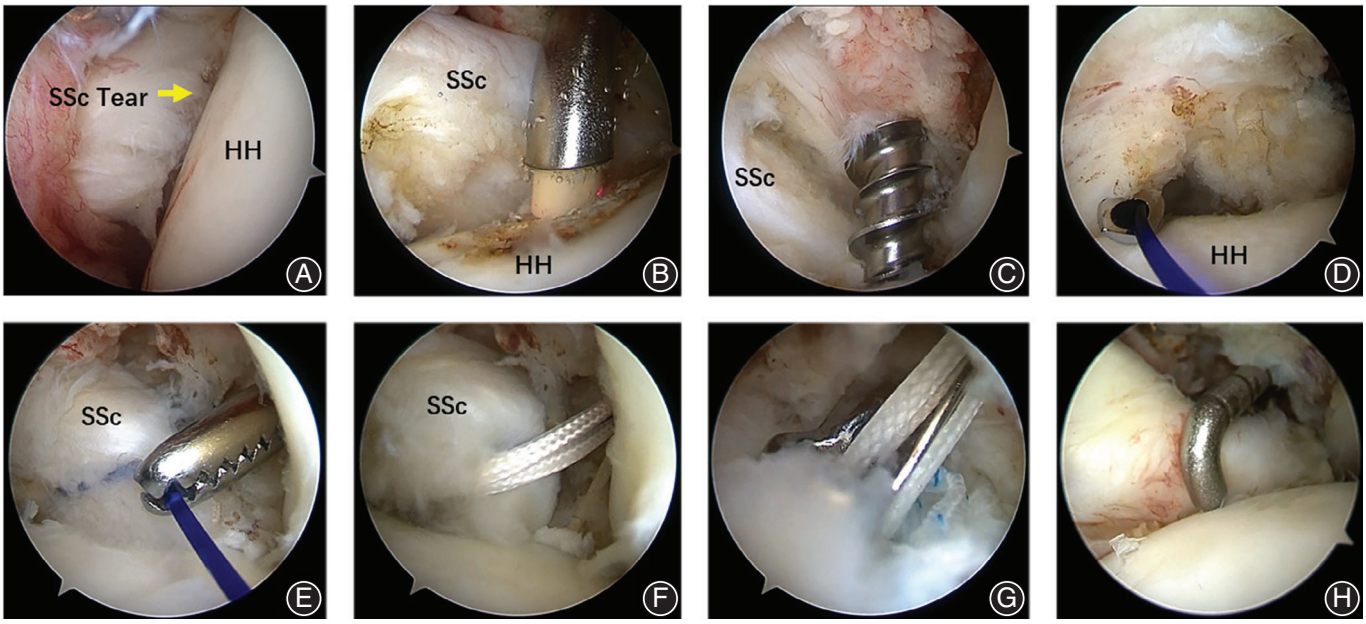

Fig. 1 Surgical procedure under shoulder arthroscopy: (A) subscapularis (SSc) tear and humeral head (HH) were identified under arthroscopy; (B) the bone bed of the footprint was prepared with a radiofrequency device; (C) the double-loaded suture anchor was placed at the upper third of the subscapularis footprint; (D) the suture lasso penetrated the full thickness of the subscapularis tendon; (E) another stitch was taken medial to the previous two stitches to create a horizontal loop; (F) the limb of the second suture thread was shuttled through the tendon and then retrieved out; (G) limbs of the suture threads were tied by sliding the arthroscopic knots on the anterior surface of the tendon; (H) a probe was used to confirm the adequacy of the fixation

To create a horizontal loop, another stitch was taken about 5 mm medial to the previous two stitches and in the middle between the superior margin and the inferior margin of the tear (Figure 1E). A limb of the second suture thread was shuttled through the tendon and was then retrieved out (Figure 1F).

The superior and inferior limbs of the first suture thread were tied by sliding the arthroscopic knots on the anterior surface of the tendon, and the excess length of the suture thread was cut using arthroscopic scissors. The two limbs of the second suture thread were tied in the same manner (Figure 1G), thereby creating an X-shaped fixation over the torn subscapularis tendon (Figure 2).

At the end of the procedure, a probe was used to confirm the adequacy of the fixation (Figure 1H).

Postoperative Protocol

The affected shoulder was immobilized for 4–6 weeks using a sling. The passive shoulder range-of-motion exercise was initiated on the day after surgery. During this period of time, passive mobilization was allowed to 90° flexion forward and 0° external rotation. Upon the end of the immobilization period, active-assisted mobilization was allowed without any

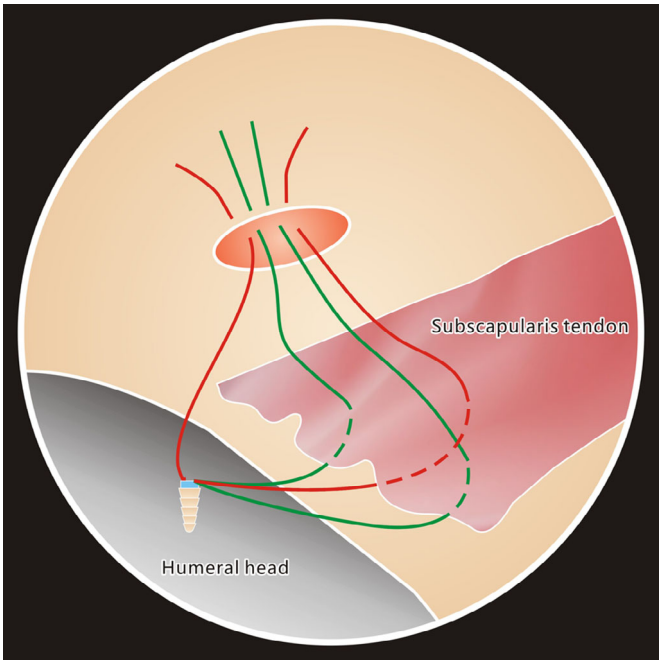

Fig. 2 An X-shaped fixation was created using one suture anchor

ROM restrictions, but the provocation of severe pain should be avoided as far as possible. Lastly, strengthening could be started after 12 weeks.

Case Presentation

Case 1

The patient, a 50-year-old man, was referred to our outpatient department due to a painful right shoulder. He sustained an injury to the affected shoulder during an accidental fall 3 years ago. Symptoms, including pain during activities and at rest, exacerbated in the recent half month and did not respond well to physiotherapy or oral nonsteroidal anti-inflammatory drugs. The tenderness to palpation over the greater and lesser tuberosities was positive. The patient was subjected to a painful arc between 60° and 120°. The testing of the rotator cuff musculotendinous unit including the empty can test, lift-off test, and belly-off sign was negative, but the patient still complained of pain. The diagnosis was established based on magnetic resonance imaging (MRI), which showed partial tears within the upper part subscapularis tendon (Figure 3A,B) and in the supraspinatus tendon.

Case 2

The patient, a 51-year-old man, had suffered left shoulder pain for 2 months with no history of trauma, and the pain was exacerbated in the last week. In the examination process, he had point tenderness over the anterior shoulder and experienced pain during all active shoulder movements. The X-ray did not show any fracture. Functional examination showed that the patient was unable to lift his left hand off

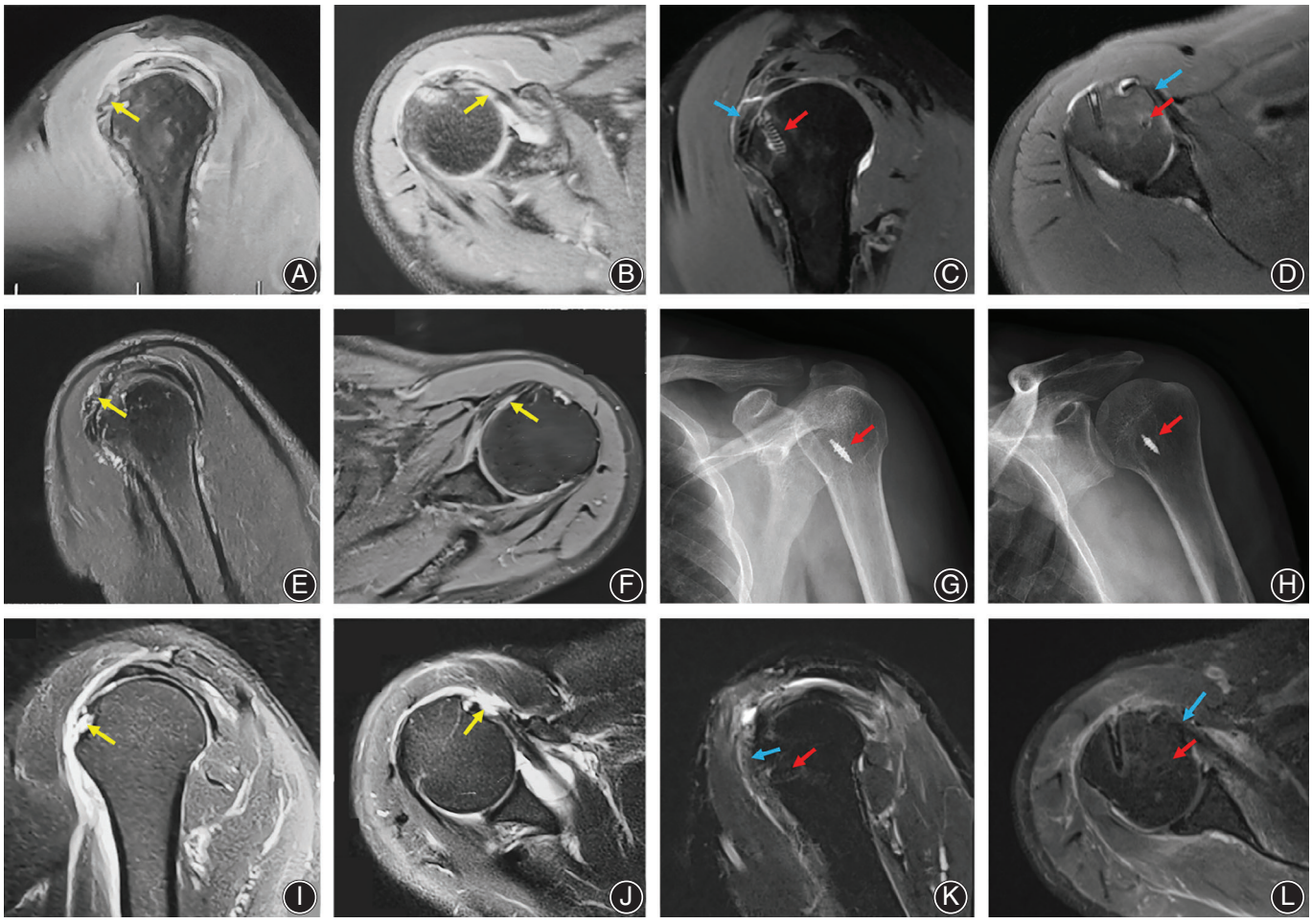

Fig. 3 Preoperative and postoperative imaging data for each case. Case 1: (A, B) preoperative MRI showing subscapularis tear (yellow arrows); (C, D) Three months postoperatively, MRI showed that the suture anchor was properly placed (red arrows) and subscapularis tendon healed well (blue arrows); Case 2: (E, F) preoperative MRI showing subscapularis tear (yellow arrows); (G, H) postoperative X-rays showed that the suture anchor was properly placed (red arrows); Case 3: (I, J) preoperative MRI showing subscapularis tear (yellow arrows); (K, L) postoperative MRI showed that the suture anchor was rightly placed (red arrows) and subscapularis tendon was well-fixed (blue arrows). MRI, magnetic resonance imaging

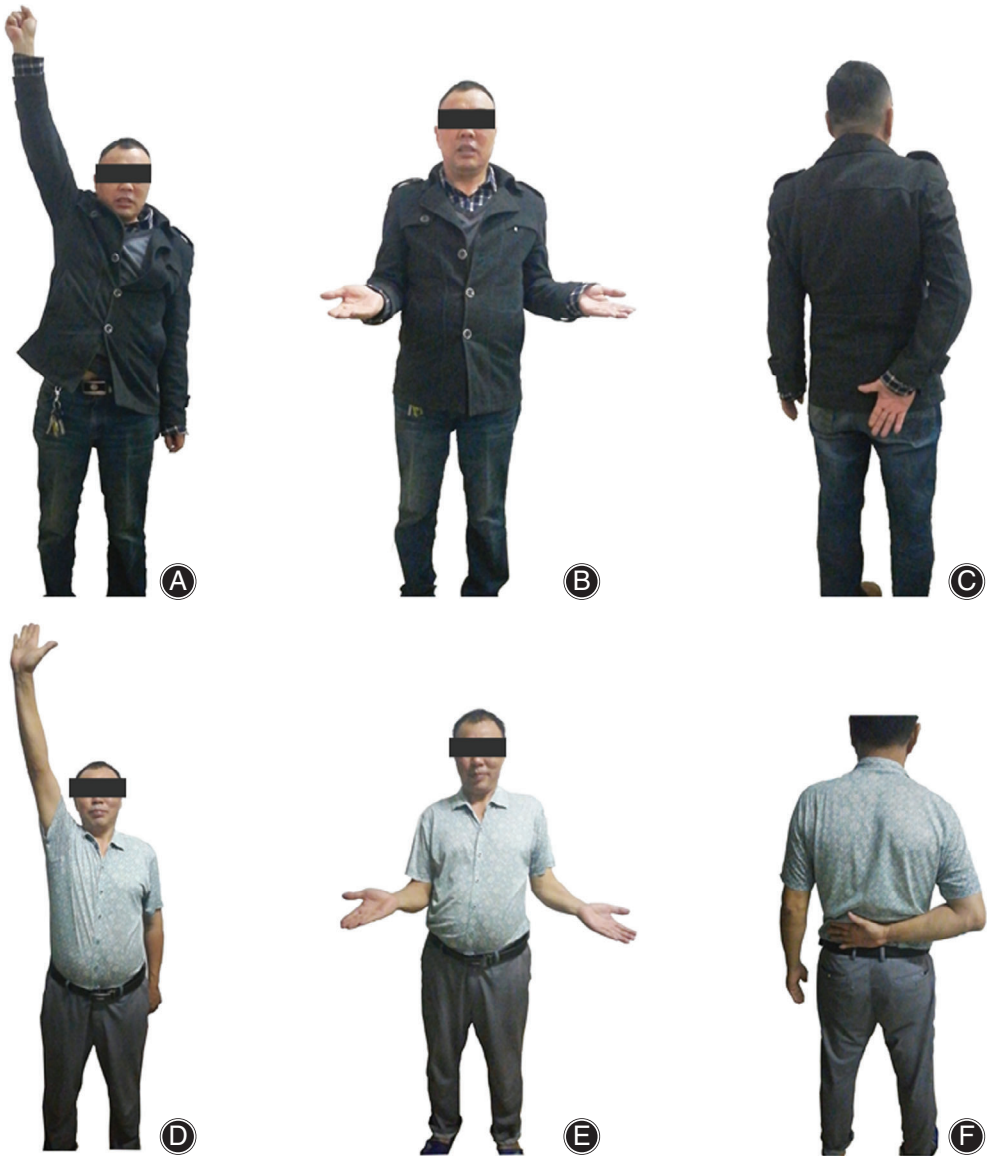

Fig. 4 Physical examination at different follow-ups for Case 1 (A–C for 3 months follow-up; D–F for 10 months follow-up)

his buttock when his arm was behind back in an internal rotation position. The patient also suffered a restricted active and passive range of motion of the left shoulder. MRI examination indicated partial rupture of the subscapularis tendon (Figure 3E,F).

Case 3

The patient, a 56-year-old man, sustained his injury in an accidental fall 1.5 months ago in which his right shoulder directly hit the ground. Taking into account the patient's painful right shoulder, mechanism of injury and internal rotation weakness, MRI examination was performed, which revealed a partial tear of the subscapularis tendon at the lesser tuberosity (Figure 3I,J) and a tear in the supraspinatus tendon.

Outcome Measures

The pre- and follow-up outcomes were evaluated using the following items: active shoulder ROM, visual analog scale (VAS), and radiographic assessments (MRI scan or X-ray).

Range of Motion

The active shoulder ROM data was collected (flexion forward, external rotation, and internal rotation). The flexion forward and external rotation degree with the arm at the side were measured with a goniometer. The internal rotation was measured by the patient's hand relating to a landmark on his or her own body: thigh, buttock, or vertebra.

Visual Analog Scale

The VAS score system was used to denote the intensity of shoulder pain. The scores range from 0 to 10. A higher score

indicated greater pain intensity. Patients described their pain intensity as 0 (no pain), 1–3 (mild pain), 4–6 (patients can tolerate pain), and 7–10 (the pain cannot be tolerated).

Results

Follow-Up

All three cases are men, and the mean age was 52.3 years (range 50–56). All three patients were followed up for 4–11 months postoperatively with an average of 8.3 months, and for at least two times.

Clinical Improvement

Shoulder Joint ROM

Case 1: Before the operation, the flexion forward of the affected shoulder was 145°, the external rotation was 15°, and the internal rotation level was buttock. Three months after the operation, the flexion forward was improved to 165° (Figure 4A), the external rotation was improved to 35° (Figure 4B), and the internal rotation was improved to L5 (Figure 4C). Ten months post-operation, the affected shoulder joint ROM for each direction was improved to 175°, 40°, and L1 (Figure 4D–F).

Case 2: The flexion forward, external rotation, and internal rotation of the affected shoulder was 30°, 10°, and thigh before the operation. Three months post-operation, the affected shoulder joint ROM for each direction was improved to 160°, 50°, and T11. At the last follow-up time point, 11 months post-operation, the ROM was improved to 175°, 60°, and T10, respectively.

Case 3: Before the operation, the ROM of the affected shoulder was 60°, 10°, and S1 for flexion forward, external rotation, and internal rotation. One month post-operation, the ROM for each direction was improved to 95°, 30°, and L4. Four months post-operation, the ROM was improved to 125°, 40°, and L1.

Visual Analog Scale

Case 1: The VAS score before the operation was 8, then decreased to 2 when followed up at 3 months after the operation. At the last follow-up time point, 10 months post-operation, the patient felt no pain during active ROM, indicating that the pain was remarkably reduced postoperatively.

Case 2: The VAS score was decreased from preoperative 8 to postoperative 1 at 3 months after the operation. Eleven months postoperatively, the VAS score decreased to 0, no matter at rest or during active activities.

Case 3: One month after the operation, the VAS score decreased remarkably from preoperative 7 to postoperative 3. Four months later, the VAS score decreased to 1, only slight pain was detected when doing active activities with the affected shoulder.

Radiographic Outcomes

Case 1: The patient received MRI examination 3 months after the operation. In the sagittal plane, the subscapularis tendon could be seen firmly attached to the lesser tuberosity and the suture anchor was properly placed both in location and depth (Figure 3C). In the axial plane, it was confirmed that the integrity and continuity of the subscapularis tendon were successfully restored and no-retear was observed (Figure 3D).

Case 2: The postoperative X-ray confirmed the proper location of the suture anchor both in anteroposterior and lateral views (Figure 3G,H).

Case 3: MRI examination was performed the day after the operation. The suture anchor was rightly placed in the lesser tuberosity, perpendicular to the bony cortex (Figure 3K). And the subscapularis tendon could be seen well-fixed in the axial plane (Figure 3L).

Complications

All incisions healed well without occurrence of infections, fractures, or nerve injuries. No long-term complication, such as shoulder stiffness, muscular weakness, or tendinitis was reported in any of these three cases.

Discussions

With the advance of modern arthroscopic techniques, encouraging outcomes have been reported for patients after arthroscopic subscapularis repair[17]. However, some surgeons hesitate to operate this procedure given a variety of concerns over arthroscopic techniques, such as it being time-consuming, technically challenging, and often requiring several working portals. In this article, we presented a simple and quick technique for arthroscopic repair of subscapularis tears by using only a single anterior portal and a single suture anchor.

Previous Techniques and Comparison

Elena *et al.*[18] performed a similar technique with a single anterior portal and found that the main limitation of their technique was associated with single anchor repair, especially for large or retracted tears. In some cases, the surgeon may encounter extensive subscapularis tear or poor tissue quality. Under such a circumstance, an additional suture anchor or a double row repair might be more appropriate, because it could facilitate the creation of a larger footprint[19]. In our procedure, it is easy to add an additional suture anchor for large and extensive subscapularis tears. If a double row repair is needed, an accessory anterolateral portal can also be easily added. Conversion from the initial single-portal approach to the two anterior portals approach can be implemented for large or retracted tears that require a double-row repair or a traction stitch[20]. Recently, Shen *et al.*[21] performed another technique using single row anchor in repairing large subscapularis tears combined with long head of the biceps tendon injury. In their study, an accessory anterolateral portal was established, and the

fixation procedure was more complicated than ours. Yet, their technique might be a better option for large subscapularis tears with concomitant long head of the biceps tendon injury.

Advantages

The most significant improvements of our technique lie in minor surgical trauma and reduced operation time, and the X-shaped fixation can provide a robust repair. In the simple old-fashioned suture fixation technique[11], tying an arthroscopic knot was accomplished without any configuration, once the suture limbs were retrieved and brought out after passing through the tendon. However, in some cases, the degenerated subscapularis tendon would easily split when making the sliding knot. Our technique, using the X-shape fixation, effectively prevented linear cut-through of the sutures in the subscapularis tendon, and provides a larger footprint coverage. Additionally, only a single anterior portal is created in this technique, so less surgical trauma is warranted. However, caution should be exercised when tying the sliding knots. Since four limbs of suture thread are retrieved from one portal, the limbs may get tangled up when tying knots. To resolve this issue, a good visualization should be achieved before tying the knots. And the limbs of the second suture loop should be tightened by the assistant when performing the first sliding knot, so as to avoid the intertwining of sutures. At last, there may be potentially a short learning curve for this technique. Less operation time also provides a possibility for treating associated injuries before fluids distend the shoulder joint and limit the visibility[22].

Limitations

One limitation of this study lies in the small sample size. Nevertheless, the purpose of this study was not to provide scientific foundation for our procedure, but rather to provide a newly introduced technique to tackle the situation of subscapularis tear. In some cases, retracted tears, extensive tears, and poor-quality tendon may require an accessory anterior portal and additional anchor fixation.

Conclusions

This article elaborates an arthroscopic intra-articular subscapularis repair procedure using an X-shaped fixation technique, which requires only a single anterior working portal for anchor placement and tear repair. This newly introduced subscapularis repair technique may be recognized as a valid treatment option for subscapularis tear in the future and can be easily reproduced by inexperienced surgeons.

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Declaration

All authors contributed significantly and met the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors. All authors agree to the final submitted manuscript.

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