



Original Article

Arthroscopic repair of partial articular supraspinatus tendon avulsion lesions by conversion to full-thickness tears through a small incision

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ABSTRACT

Purpose: To assess the clinical efficacy of converting partial articular supraspinatus tendon avulsion (PASTA) lesions to full-thickness tears through a small local incision of the bursal-side supraspinatus tendon followed by repair.

Methods: We retrospectively analyzed 41 patients with Ellman grade 3 PASTA lesions and an average age of (54.7 ± 11.4) years from March 2013 to July 2017. Patients without regular conservative treatment and concomitant with other shoulder pathologies or previous shoulder surgery were excluded from the study. The tears were confirmed via arthroscopy, and a polydioxanone suture was placed to indicate the position of each tear. A small incision of approximately 6 mm was made using a plasma scalpel on the bursal-side supraspinatus tendon around the positioned suture to convert the partial tear into a full-thickness tear. The torn rotator cuff was sutured through the full thickness using a suture passer after inserting a 4.5-mm double-loaded suture anchor. Data were analyzed using a paired Student's *t*-test with statistical significance defined as $p < 0.05$.

Results: At the final follow-up of 2 years, the pain-free shoulder joint range of motion and visual analog scale score were significantly improved compared to those before surgery ($p < 0.001$). The postoperative American Shoulder and Elbow Surgeons shoulder score was (90.6 ± 6.2), which was significantly higher than the preoperative score of (47.9 ± 8.3) ($p < 0.001$). The University of California at Los Angeles shoulder rating scale score increased from (14.7 ± 4.1) prior to surgery to (32.6 ± 3.4) points after surgery ($p < 0.001$). No patient had joint stiffness.

Conclusion: This modified tear completion repair, by conversion to full-thickness tears through a small incision, has less damage to the supraspinatus tendon on the side of the bursa compared to traditional tear completion repair in the treatment of PASTA lesions. This surgical method is a simple and effective treatment that can effectively alleviate pain and improve shoulder joint function.

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Introduction

Although partial-thickness rotator cuff tears were first described in 1934 by Codman,¹ additional information about these tears was revealed after the widespread application of shoulder arthroscopy and magnetic resonance imaging (MRI). Ellman divided partial-thickness rotator cuff tears into three types according to their locations: articular-side lesions (type A), bursal-side lesions (type B) and intratendinous lesions (type C). According to the extent of injury, Ellman also classified lesion severity into 3 grades according

to the thickness of the tear: grade 1 tears: <3 mm, grade 2 tears: between 3 mm and 6 mm, and grade 3 tears: > 6 mm.² The incidence rate of rotator cuff injury is 17%–37%, with articular-side tears being 2–3 times more common than bursal-side tears.^{3,4} A previous study analyzed the anatomical distribution of rotator cuff tears and found that approximately 50% of tears were located at the articular surface and mainly involved the supraspinatus tendon.⁵ Snyder first proposed the concept of a partial articular supraspinatus tendon avulsion (PASTA) lesion, which refers to tears of the supraspinatus tendon at the articular surface.⁶

Articular-side supraspinatus tendon tears are a common cause of shoulder joint pain and dysfunction, and the resulting pain symptoms are more pronounced than those of bursal-side tears.^{7,8} Conservative treatment could be performed as the first option for

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PASTA lesions, functional exercises, physical therapy, nonsteroidal drugs, and including optional use of biological adjuvants such as injection of platelet-rich plasma.^{8–11} The current literature suggests a surgical repair for PASTA lesions with failed conservative treatment and an injury severity greater than 50% (type A3) to prevent tear progression.^{4,12–14} In situ transtendinous repair and repair after converting tears to full-thickness tears under arthroscopy are common methods for the surgical repair of PASTA lesions in clinical practice, but no evidence indicates which technique is superior for PASTA lesion repair.^{4,12,15–19} We reported 41 patients with PASTA lesions that were converted to full-thickness tears through a small local incision of the corresponding bursal-side supraspinatus tendon under arthroscopy followed by suture repair. A comparison of preoperative and postoperative clinical results showed that the treatment effects were satisfactory.

Methods

Patient information

We retrospectively analyzed 41 patients with simple PASTA lesions that were converted to full-thickness tears via small incisions under arthroscopy and then repaired between March 2013 and July 2017. Among the patients (18 males, 23 females), 25 had tears in the right shoulder and 16 in the left shoulder. The age range was 31–75 years, and the average age was (54.7 ± 11.4) years. The surgical indications included: (1) simple PASTA lesions with MRI results showing a tear depth of at least 50% (Ellman type A3), and (2) at least 3 months of conservative treatment with poor efficacy and persistent pain and functional impairments affecting a patient's life. Exclusion criteria were (1) previous surgery history in the affected shoulder, (2) other combined shoulder pathologies needed simultaneous surgical management (including greater tuberosity fractures, superior labrum anterior and posterior (SLAP) lesions, Bankart lesions, and bicep tendon or other rotator cuff tissues ruptures on the same shoulder), (3) patients with PASTA lesions who did not undergo regular conservative treatment.

Surgical technique

Following general anesthesia induction and a brachial plexus block, the patient was positioned on his or her side with the affected limb under slight anterior flexion and traction. The glenohumeral joint was routinely examined through the posterior channel by arthroscopy. Articular-side supraspinatus tendon tears were easily identified in the upper part of the articular cavity at the 11:00 to 1:00 position (Fig. 1A). The tear site of the articular-side supraspinatus tendon was cleared with a planer through the anterior channel, and the tear was examined with a probe to measure its depth and extent. Ellman grade 3 injury was determined if the depth of the articular surface tear was >6 mm and exceeded 50% of the thickness of the tendon. A $0.7 \text{ mm} \times 80 \text{ mm}$ injection needle was placed in the middle of the articular-side supraspinatus tendon tear in the articular cavity after passing through the deltoid muscle from the skin under the lateral edge of the acromion. A #0-polydioxanone suture (PDS) (Ethicon, Somerville, NJ) was inserted into the articular cavity through the needle (Fig. 1B). Then, the PDS was pulled out of the articular cavity through the anterior channel before the puncture needle withdrawn. The arthroscope was advanced into the subacromial region, clearing the subacromial bursa, and the rotator cuff footprint was exposed. Acromioplasty was performed if a curved or hooked acromion was present (a Bigliani type II or III acromion). The bursal-side rotator cuff was examined to observe whether it was intact and whether degeneration had occurred. After locating the positioned

PDS, the bursal-side supraspinatus tendon was incised for approximately 6 mm around the PDS using a plasma scalpel (Arthrocare, USA) to convert the tear into a full-thickness tear (Fig. 1C). After the PDS was removed, the bone surface to which the tendon was attached was treated with a planer. A 4.5-mm double-loaded suture anchor (TWINFIX Ultra PK, Smith & Nephew, USA) was inserted into the footprint (Fig. 1D). Then from near the anterior and posterior end of the tear site, one limb of a suture of 2 sutures on the anchor was passed through the full thickness of the articular and bursal surfaces of the supraspinatus tendon using a suture passer (Arthrex, USA) (Fig. 1E) and the distance between the two threads was maintained at approximately 1 cm. All suture limbs were tied on the bursal side of the tendon after retrieved through the lateral portal. Arthroscopic examination and evaluation of the articular-sided tendon after repair from the posterior portal (Fig. 1F).

Postoperative recovery

All patients underwent the same postoperative recovery exercise protocol. For six weeks after surgery, the affected shoulder was placed in a shoulder abduction brace at 0° of external rotation and 15° of abduction. Starting from the first day after surgery, the patients were encouraged to perform flexion and extension exercises of the elbow joint and wrist joint, as well as pendulum movements and passive external rotation under the guidance of a physiotherapist to prevent stiffness of the shoulder joint. Six weeks after surgery, the shoulder abduction brace was removed, and the patients started performing active movements. Resistance shoulder movement training was started three months after the operation.

Assessment of clinical efficacy

Physicians who were not involved in this study preoperatively and postoperatively measured the shoulder joint range of motion (ROM) using an angle goniometer, assessed pain in the affected shoulder using the visual analog scale (VAS), and assessed shoulder joint functions using the American Shoulder and Elbow Surgeons (ASES) shoulder score and the University of California at Los Angeles (UCLA) shoulder rating scale.

Statistical analysis

All continuous variables are represented by the mean \pm standard deviation (SD). SPSS 22 (IBM, Armonk, NY, USA) was used for the statistical analysis. A value of $p < 0.05$ was considered statistically significant, and 95% confidence intervals (CI) were determined. The preoperative and postoperative ROM, VAS score, ASES shoulder score and UCLA shoulder score were analyzed by paired *t*-tests.

Results

Forty-one patients with Ellman grade 3 PASTA lesions were treated with this surgical method, and all patients were followed up for at least 24 months (range 24 – 44 months, median 31 months). No patients failed by this surgical method and needed revision operation. No patients had joint stiffness or restricted mobility during the follow-up period. Moreover, no other special postoperative complications were recorded. At the final follow-up, the shoulder joint ROM, VAS score, ASES shoulder score and UCLA shoulder score were significantly improved. Pain-free ROM increased significantly compared to that prior to surgery ($p < 0.001$) (Table 1). The VAS pain score (with 0 points indicating no pain and 10 points indicating maximum pain) changed significantly from a

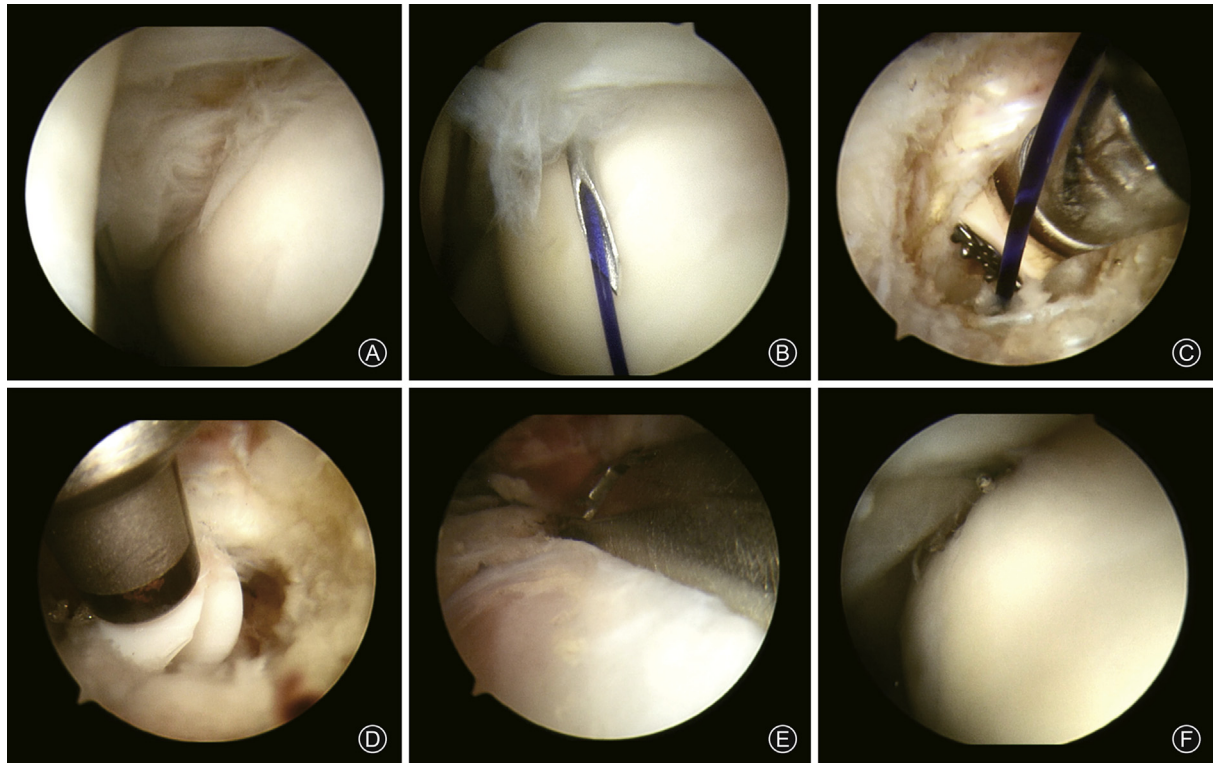


Fig. 1. (A) Intra-articular view of a partial articular supraspinatus tendon tear in the left shoulder is viewed from the posterior portal; (B) A 0.7 mm × 80 mm needle is placed in the middle of the torn tendon in the articular cavity from the skin under the lateral edge of the acromion. A #0-polydioxanone suture was inserted into the articular cavity through the needle. (C) A posterolateral subacromial view of a small incision is made on the bursal-side supraspinatus tendon around the PDS by using a plasma scalpel (Arthrocare); (D) A 4.5-mm double-loaded suture anchor (TWINFIX Ultra PK, Smith & Nephew) is placed at the footprint exposed in the middle of the torn supraspinatus tendon; (E) Two suture limbs are passed from the articular surface to the synovial bursa layer of the torn supraspinatus tendon with a suture passer through the anterolateral portal; (F) The arthroscope enters the glenohumeral joint cavity from the posterior portal, and it can be seen that the torn articular-sided tendon is retracted after repair.

Table 1
Changes in shoulder joint range of motion.

Range of motion	Preoperative ^a	Final follow-up ^a	<i>t</i> value	<i>p</i> value
Forward elevation	131.6±9.7	165.8±11.2	14.8	<0.001
External rotation	58.7±10.4	81.5±12.6	8.9	<0.001
Internal rotation	44.5±14.3	67.9±10.6	8.4	<0.001

^a Data are presented as mean ± standard deviation. External rotation and internal rotation range of motion were assessed in 90° of shoulder abduction.

preoperative value of (7.1 ± 3.6) points to a postoperative value of (1.1 ± 2.9) points ($p < 0.001$). Regarding shoulder function improvement, the ASES shoulder score increased from a preoperative value of (47.9 ± 8.3) points to a postoperative value of (90.6 ± 6.2) points ($t = 19.8$, $p < 0.001$), and the UCLA shoulder score increased from a preoperative value of (14.7 ± 4.1) points to a postoperative value of (32.6 ± 3.4) points ($t = 16.1$, $p < 0.001$) (Table 2).

Discussion

The main finding of this study was that arthroscopic repair of articular-side supraspinatus tendon tears by conversion to full-

Table 2
Assessment of shoulder joint function.

Score system	Preoperative ^a	Final follow-up ^a	<i>p</i> value
ASES shoulder score	47.9 ± 8.3	90.6 ± 6.2	<0.001
UCLA shoulder rating scale	14.7 ± 4.1	32.6 ± 3.4	<0.001

^a Data are presented as mean ± standard deviation. ASES: American Shoulder and Elbow Surgeons, UCLA: University of California at Los Angeles.

thickness tears through a small incision for the treatment of PASTA injury showed excellent clinical results during the 24-month follow-up period. Besides, no cases of limitation of joint stiffness and movement were found during the follow-up. All patients had good functional recovery and high subjective satisfaction in pain relief. The mechanisms of PASTA injury include impingement, instability, trauma, and intrinsic tendon degeneration associated with changes in tendon blood supply and other related factors. Histological studies have shown that the blood supply of the rotator cuff is poor at the articular surface, the fiber alignment is disordered, and the tear location undergoes degenerative changes.^{20–22} Therefore, the self-healing potential of articular-side supraspinatus tendon tears is limited. A study by Yamanaka et al.²³ showed that when conservative treatment was used for PASTA lesions, 53% of patients showed a trend of increased severity of supraspinatus tendon tears, and 28% of patients developed full-thickness tears.

Arthroscopic treatments for PASTA lesions include local debridement with or without subacromial decompression and in situ transtendinous repair or repair after conversion of the lesion to a full-thickness tear.¹² Some studies have shown the good efficacy for rotator cuff debridement and acromioplasty for partial rotator cuff tears at the articular surface.^{24–26} However, patients treated only with acromioplasty and debridement could alleviate pain but could not prevent the progression of rotator cuff tears, and most cases of Ellman grade 3 tears need to be repaired to restore better shoulder function.^{27–29}

For articular-side supraspinatus tendon tears, the decision to perform transtendinous repair or repair after conversion of the lesion to a full-thickness tear remains controversial. Both surgical

methods have advantages and disadvantages. The PASTA transtendinous repair method retains the entire bursal side of the supraspinatus tendon and simultaneously repairs the articular surface. Many studies have reported satisfactory clinical results for the transtendinous repair method in the surgical treatment of PASTA lesions.^{4,30–33} However, a recent systematic review showed that the transtendinous anchor repair method resulted in a long duration of shoulder joint pain during postoperative recovery and a high incidence of shoulder joint stiffness of up to 18%,³⁴ which may be due to the longer operative time in the articular cavity and increased disturbance of the articular cavity during transtendinous anchor repair. Also, the trans-tendon repair inevitably caused a certain degree of injury to the intact bursa tendon. Trans-tendon arthroscopic repair is relatively complicated, and the technical requirements for the surgeon performing the arthroscopic surgery are increased.

The most significant advantage of converting a tear to a full-thickness tear that is repaired by arthroscopy is that the procedure is familiar and easy to perform. Previous studies have confirmed that converting PASTA lesions into full-thickness tears prior to suture and repair results in satisfactory clinical efficacy, and full-thickness suture repair can reduce the time required for alleviation of shoulder joint pain and functional recovery of the shoulder joint.^{34–36} To some extent, by converting a supraspinatus tendon lesion into a full-thickness tear before repair, the bone and tendon produce a scar instead of a fibrocartilage connection, which can easily lead to a reoccurrence of tearing and therefore limits the application of the full-thickness tear and suture technique.³⁷ However, comparison of the two surgical methods also shows that the occurrence of re-tearing after converting a PASTA lesion to a full-thickness tear and the resulting repair of the lesion do not differ significantly from those of trans-tendon repair.^{15,17} After confirming the presence of an Ellman grade 3 PASTA lesion using arthroscopy, we applied a modified completion and repair to surgical treatment. A 4.5-mm double-loaded suture anchor was placed at the exposed footprint after a small incision was made at the corresponding bursal surface using a plasma scalpel after locating the marking suture. Then, using a suture passer through the incision to the shoulder joint cavity, the sutures were passed through the articular side and tied on the bursal side of the tendon. By contrast to the traditional method, this modified takedown and repair way is no need to open the tendon tissue of the bursa side in a large range and has less damage to the bursal-side supraspinatus tendon. As compared with the trans-tendon repair, excepting less interference to the joint cavity, the suture anchor placement is more simple and straightforward. It should be mentioned that the depth of the suture passer into the joint must be sufficient to ensure that the suture enters from the articular side of the supraspinatus tendon and passes out of the corresponding bursa side.

Some limitations exist in this study. We did not set up a control group in our study. In addition, the number of patients was limited, the follow-up time was not sufficiently long, and the integrity of tendon repair was not assessed by MRI during the follow-up. More long-term studies are needed to confirm and compare the reliability of the outcomes of this procedure.

In conclusion, arthroscopic repair of PASTA lesions by conversion to full-thickness tears through a small incision is an effective and easy-to-perform surgical method. This method can minimize bursal-side supraspinatus tendon injury, effectively alleviate pain and improve shoulder joint function.

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Ethical Statement

The study has been approved by the Committee of Research Ethics Institutions, and informed consent was obtained from all patients or their relatives.

Declaration of Competing Interest

The author states that no potential conflict of interest related to the study, the author and/or publication of this article exists. The author did not receive any financial support for the study and/or publication of this article.

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