Clinical and Magnetic Resonance Imaging Results of Arthroscopic Repair of Intratendinous Partial-thickness Rotator Cuff Tears

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Abstract

Background: Partial-thickness rotator cuff tears (PTRCTs) are being diagnosed more often because of high-resolution magnetic resonance imaging (MRI). Compared with articular and bursal side tears, there have been few studies about evaluating the clinical and structural outcomes after intratendinous tear repair.

Methods: From 2008 to 2012, 33 consecutive patients with intratendinous PTRCTs underwent arthroscopic repair. All of them were retrospectively evaluated. The University of California at Los Angeles (UCLA) and constant scores were evaluated before operation and at the final follow-up. Postoperative cuff integrity was determined using MRI according to Sugaya’s classification.

Results: At the 2-year follow-up, the average UCLA score increased from 16.7 ± 1.9 to 32.5 ± 3.5, and the constant score increased from 66.2 ± 10.5 to 92.4 ± 6.9 (P < 0.001). Twenty seven patients received follow-up MRI examinations at an average of 15.2 months after surgery. Of these 27 patients, 22 (81.5%) had a healed tendon, and five patients had partial tears. There was no association between functional and anatomic results.

Conclusions: For intratendinous PTRCT, clinical outcomes and tendon healing showed good results at a minimum 2-year after arthroscopic repair.

Key words: Arthroscopic Repair; Intratendinous Tear; Partial-thickness Tear; Rotator Cuff; Shoulder

INTRODUCTION

Partial-thickness rotator cuff tears (PTRCTs) have the potential to cause significant pain and disability in affected patients. The approach to these patients should begin with a trial of nonoperative treatment. After failed conservative management, operative intervention is typically indicated for patients with persistent symptoms. Surgical treatment is generally limited to tear debridement with or without acromioplasty or tear repair with or without acromioplasty. Most authors recommend repair of tears involving 50% or more of the tendon thickness.

With the advent of magnetic resonance imaging (MRI) and shoulder arthroscopy, more PTRCTs are being recognized. Unfortunately, high-quality data on the management of PTRCTs are relatively lacking in the literature when compared with those available on full-thickness tears.

Partial-thickness rotator cuff tears are classified into three subtypes: Bursal side, articular side, and intratendinous tears. Among them, intratendinous tears are an important clinical entity. Intratendinous tears are characterized by the absence of fiber disruption on both the bursal and articular surface of the rotator cuff. Intratendinous PTRCTs may be more common than previously recognized. A cadaveric study reported that this type of tear was the most frequent (55%) among all of the partial-thickness tears.[1] Other studies have reported a clinical incidence of 7.9%–25.6%[1] for intratendinous tears.

Because the intratendinous tear has no communication to the subacromial space and the glenohumeral joint, it is probably the most difficult condition to be diagnosed among the three types of the partial tear.[4,5] MRI may be a useful modality for diagnosing intratendinous tears. However, confirmation of such lesions during operation can be difficult. Only a few literature described how to find the intratendinous tears during surgery.[2,4,5]

Both bursal side and articular side rotator cuff tears have been extensively studied, but little has been written about...
intraditendinous tears.[2-4] Although arthroscopy has led to an increase in treatment of PTRCTs, there were only few case reports concerning about arthroscopic repair of intraditendinous tears. In addition, no one reported the structural outcomes after arthroscopic repair of intraditendinous tears. The purpose of this study was to evaluate the functional results and structural outcomes after arthroscopic repair of intraditendinous PTRCTs. Our hypothesis was that arthroscopic repair of intraditendinous PTRCTs could achieve good clinical and structural results.

**Methods**

This study received approval from the Investigational Review Board.

**Patient selection**

From February 2008 to April 2012, 36 consecutive patients (36 shoulders) with intraditendinous tears underwent arthroscopic treatment. All the intraditendinous tears were confirmed during the operation. The inclusion criteria in this study were (1) Symptoms lasting more than 3 months with proper conservative treatment and (2) no major associated pathology that would need to be addressed at the time of arthroscopic surgery, such as a frozen shoulder or Bankart lesion. Three patients with frozen shoulder were excluded from this study. Therefore, 33 patients met the inclusion criteria and were retrospectively studied. All of the 33 patients (33 shoulders) were available for evaluation of clinical follow-up. There were 16 men and 17 women. The mean age at the time of surgery was 42.9 ± 9.9 years (range, 22–61 years). A total of 18 (54.5%) patients had repair of the dominant shoulder, with 15 left and 18 right shoulders involved.

**Preoperative clinical features**

A history of acute trauma was present in 13 patients. Sixteen patients experienced persistent pain, including night pain. Seventeen patients complained of pain during shoulder movement. All of the patients had positive Neer or Hawkins impingement signs. The active range of motion (ROM) was 155° (range, 60°–180°) in flexion, 156° (range, 45°–180°) in abduction, 43° (range, 15°–55°) in external rotation, and active internal rotation was L3 (range, T7–gluteus). The passive ROM was normal in each patient.

**Preoperative images**

Preoperatively, all of the patients received bilateral radiographs of anteroposterior and supraspinatus outlet views and a noncontrast MRI examination. 1.5-Tesla MRI system was used with patients’ arm in a neutral position. Oblique sagittal, oblique coronal and transverse, T2-weighted fat-depressed, fast spin echo images were acquired for all shoulders. The diagnostic signs of intraditendinous tears included a defect within the rotator cuff and fluid-intensity signals within the tendons, which did not connect to the surface of the tendon. Depending on the serial oblique coronal images, we could estimate the distance between the center of the tear and the long head of the biceps tendon (BT) (slice thickness was 4 mm). This enabled us to identify the tear in the operation more easily.

**Conservative treatment**

Before operation, all of the patients received conservative treatment for at least 3 months. Conservative therapy comprised rest, modification of activities, local application of heat or cold, nonsteroidal anti-inflammatory medication, subacromial steroid injection, gentle exercises for maintaining and increasing ROM, and muscle-strengthening exercises.

**Surgical technique**

All of the arthroscopic procedures were performed with the patient under general anesthesia in the beach-chair position. Diagnostic arthroscopy was performed, and intra-articular pathology was treated in the appropriate manner. The tear was then localized preliminarily under arthroscopic visualization. According to the distance between the long head of the BT and the tear, which was estimated on preoperative MRI, we percutaneously penetrated the cuff with a spinal needle near tendon insertion to the humeral head. To determine this distance as accurately as possible (errors can be made as a result of the magnifying effect of the arthroscope), the width of the long head of the BT (approximately 6 mm) was taken as a guide. A No. 1 polydioxynone (PDS) suture (Ethicon, Somerville, NJ, USA) was introduced through the spinal needle, and the needle was then removed [Figure 1].

The arthroscope was then redirected into the subacromial space. The hypertrophic bursal tissue was removed. Formal acromioplasty was performed in all of the patients. When looking through the posterolateral portal, marking suture could be found in the subacromial space. Careful evaluation of the cuff insertion was then performed around the PDS suture [Figure 2]. The bursal surface was intact in all of the patients, but some areas of the tendon insertion appeared soft and lax as the tendon was palpated using a hooked probe [Figure 3]. After inserting the probe into the

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**Figure 1:** Arthroscopic view from a posterior glenohumeral portal of a right shoulder shows introduction of a polydioxynone marking suture through supraspinatus tendon. The articular side tendon is intact. HH: Humeral head; BT: Biceps tendon (note: All arthroscopic views are of right shoulders oriented in the beach-chair position).
center of the suspected lesion within the midsubstance of the tendon, a cavity within the tendon could be felt and the probe could easily touch the bone trough on the greater tuberosity [Figure 4].

After confirming the intratendinous tear, the bursal side tendon was incised. An obvious defect was present within the tendon. All the degenerative tissues of the tendon were removed until normal articular side tendon fibers were identified as being inserted into the greater tuberosity [Figure 5]. A cancellous bed was prepared at the site of the repair by removal of a thin layer of cortical bone with a power burr to promote healing of the reattached cuff. Standard single-row repair was performed with one or two suture anchors according to tear length [Figure 6].

**Rehabilitation**

The arm was maintained in a sling at 15° of abduction and neutral rotation for 6 weeks. Gentle pendulum exercises and passive external rotation were started on postoperative day 1. An ice bag was used to decreased swelling and pain. Passive ROM exercises were initiated with minimal loads across the repair for weeks 1–6. Six weeks later, active ROM exercises that progressively applied loads to the repair construct were allowed. Strengthening exercises that focused on restoring power and endurance to the healed rotator cuff muscles began after 3 months and were continued until 4–6 months postoperatively. The ROM and strengthening exercises were continued for 1 year.

**Clinical and magnetic resonance imaging evaluations**

The University of California at Los Angeles (UCLA) [7] shoulder score and the constant score [8] were used before the operation and at the final evaluation. MRI was performed to evaluate the postoperative cuff integrity. Tendon healing was classified into five types according to Sugaya’s criteria as follows: Type I, sufficient thickness compared with a normal cuff with homogenously low intensity on each image; type II, sufficient thickness compared with a partial high-intensity area; type III, insufficient thickness with less...
than half the thickness without discontinuity, suggesting a partial-thickness, delaminated tear; type IV, presence of a minor discontinuity in only one or two slices on both oblique coronal and sagittal images, suggesting a small, full-thickness tear; and type V, presence of a major discontinuity observed in more than two slices on both oblique coronal and sagittal images, suggesting a medium or large, full-thickness tear.

**Statistical analysis**

Preoperative and postoperative clinical scores were compared using the paired Student’s t-test. Postoperative clinical scores between patients with intact cuff and patients with retears were compared using an independent t-test. \( P < 0.05 \) was considered to be statistically significant.

**RESULTS**

**Preoperative imaging findings**

Preoperative plain radiographs showed type II acromion in 26 patients and type III acromion in seven patients. On oblique, coronal T2-weighted fat-depressed images from 33 preoperative MRIs, 26 patients showed an area of high-signal intensity within the insertion of the supraspinatus tendon, supporting the diagnosis of intratendinous tears [Figure 7]. Two patients showed a tendon defect, three showed high signal on the bursal surface of the tendon, and two showed tendon degeneration. These were interpreted as two full-thickness tears, three bursal side partial tears, and two normal tendons preoperatively.

**Intraoperative findings**

The intratendinous tears, which were confirmed under the arthroscopy, were found within the supraspinatus tendon in all of the patients. The coracoacromial ligament surface was fibrillated or rough in all of the patients, indicating the presence of subacromial impingement. Some intra-articular lesions were defined and treated, including two repairs and one debridement of superior labrum anterior and posterior lesion, one debridement of partial rupture of the long head of the BT, one debridement for partial tear of the subscapularis tendon, and three debridements of labrum lesions.

**Clinical outcomes**

The mean follow-up was 44.9 months (range, 24–74 months). Seventeen patients had no pain, 13 patients felt light pain or discomfort occasionally while three patients felt pain during strenuous exercise. The active ROM was 178° (range, 160°–180°) in flexion, 176° (range, 150°–180°) in abduction, 46° (range, 40°–50°) in external rotation, and active internal rotation was T12 (range T7–L3). Both scoring systems reflected significant improvement in the status of the shoulder when the preoperative scores were compared with those at the time of the final follow-up [Table 1]. The mean postoperative UCLA score and constant score were significantly higher compared with that preoperatively (\( P < 0.001 \)). No significant difference in either postoperative score was found between patients with an intact cuff and those with a cuff retear (UCLA: \( P = 0.696 \), Constant: \( P = 0.834 \)) [Table 2].

**Magnetic resonance imaging outcomes**

A total of 27 (81.8%) patients received postoperative MRI, which was performed at a mean of 15.2 months after surgery.

| Table 1: Preoperative and postoperative clinical scores (n = 33) |
|---------------------------------------------------------------|
| Period | UCLA score | Constant score |
|--------|------------|----------------|
| Preoperative | 16.7 ± 1.9 | 66.2 ± 10.5 |
| Postoperative | 32.5 ± 3.5 | 92.4 ± 6.9 |

UCLA: University of California at Los Angeles.

| Table 2: Comparison of functional outcomes between patients with an intact rotator cuff and those with a retear |
|---------------------------------------------------------------|
| Groups | UCLA score | Constant score |
|--------|------------|----------------|
| Intact group (n = 22) | 32.1 ± 2.6 | 91.0 ± 5.8 |
| Retear group (n = 5) | 31.6 ± 3.2 | 90.4 ± 7.9 |

UCLA: University of California at Los Angeles.

![Figure 6: Arthroscopic view from a posterolateral subacromial portal shows the completed single-row repair.](image)

![Figure 7: Preoperative T2-weighted magnetic resonance imaging showing an intratendinous tear (black arrow).](image)
after surgery (6–45 months). There were four type I [14.8%, Figure 8a], 18 type II [66.7%, Figure 8b], and five type III retears [18.5%, Figure 8c]. In this study, we did not find any type IV or V retears. Overall, there were 22 intact repaired cuff tendons (Sugaya’s type I or II) and five partial tears (Sugaya’s type III).

**DISCUSSION**

To the best of our knowledge, this is the largest study to examine the clinical and anatomical results of intratendinous PTRCTs after arthroscopic repair. The combination of decompression and repair with preservation of as much of the intact articular tendon fiber as possible yields a satisfactory clinical outcome. Postoperative MRI also showed a high rate of healing of the repaired tendon among our patients.

Partial-thickness rotator cuff tear is more difficult to diagnose than a full-thickness tear.[10] In particular, preoperative diagnosis of intratendinous tears may be the most challenging among the three subtypes of PTRCTs.[4,5] However, in recent years, advancement in MRI, specifically sequence alteration and differential arm positioning, have greatly improved its accuracy in identifying intratendinous tears. Previous studies have reported two kinds of signals which indicate intratendinous tears. One is a linear high signal within the tendon, which is parallel to the direction of tendon fibers.[5] The other is a focal defect at the tendon insertion, which has no communication with either surface of the tendon.[4] In the current study, 26 of 33 (78.8%) patients had been diagnosed with intratendinous tears by preoperative MRI, showing that MRI is an effective way of diagnosing intratendinous tears.

Although preoperative diagnosis has become more accurate, intraoperative localization of the tears remains problematic. This difficulty is due to the absence of overt tendon disruption on both the bursal and articular surfaces of the cuff. In Uchiyama et al.’s study,[5] a definitive diagnosis was established by a longitudinal split of the supraspinatus tendon in the area of softening, fraying, edema, erosion, and redness. Itoi and Tabata[2] reported three cases where intratendinous tear was suspected when the cuff was soft, fluffy, and bulged when the arm was elevated. Then the tears were confirmed after the cuff was incised. Under arthroscopy, Lo et al.[4] described “bubble sign” as facilitating the diagnosis of intratendinous tears. In our study, with the help of the marking suture, the inspected area could be minimized, and the tears could be found quickly.

Literature concerning the operative treatment of intratendinous PTRCTs is rare. Uchiyama et al.[5] reported 19 patients who underwent open surgery. The intratendinous tear was excised in 15 patients, including the whole lesion and a small portion of the greater tuberosity. The tendon defect was then closed by side-to-side sutures and transosseous sutures. Itoi and Tabata[2] reported three cases in which a full-thickness cuff involving the tear was resected and repaired. Lo et al.[4] reported one patient who received arthroscopic repair. A suture anchor was inserted into the lateral bone bed. The tendon was then secured using standard retrograde suture passage.

Few studies have investigated the effectiveness of acromioplasty alone for the treatment of intratendinous tears. Fukuda et al.[9] showed in their histological study that partial-thickness tears have essentially no ability to heal themselves over time. Intratendinous tears biopsied at the time of operative intervention show granulation tissue with rounded, avascular tissue margins without evidence of healing. Biomechanical studies[11,12] have shown that in the presence of a partial-thickness tear, the strain patterns within the remaining intact rotator cuff change, potentially predisposing the tissue to tear propagation. Uchiyama et al.[5] proposed that decompression alone is not a direct solution to the pathophysiology of tears. According to the results of these studies, tendon repair with acromioplasty may be more suitable.

In the current study, intratendinous tears were converted to bursal side tears after the normal bursal side tendon was incised. There is still controversy on the suturing method for bursal side tears. Some authors[13,14] have proposed to complete a full thickness tear and repair it, whereas others[15‑17] believe that the normal articular sided tissue should be reserved because it can protect the repaired bursal side tendon and offer a good opportunity for healing of the repaired tendon. In addition, with preservation of an intact articular side tendon, some authors[16,17] tend to perform a full-layer repair whereas others[15,18] prefer to repair the outer layer only. In the present study, we preserved the healthy articular side tendon as much as possible and repaired the bursal flap back to the bone. Good clinical and structural results showed that our technique was effective for intratendinous tears.

To the best of our knowledge, few studies have examined structural outcomes after arthroscopic repair of intratendinous
Whether the tendon integrity affect the clinical result is under debate. Some authors believed that retearing had no effect on the clinical results, especially in small tears. Our results are consistent with these reports. However, further studies are needed to clarify the reason of this interesting finding.

This study has several limitations. First, this was a retrospective study with a relatively small number of patients and a relatively short time of follow-up. Therefore, this study does not provide a clear understanding of the requirement for treatment of intratendinous rotator cuff tears. Second, because we did not perform subacromial decompression alone to the intratendinous tears, we could not compare both results. Third, postoperative MRI scans were taken at 6 months to 4 years (i.e., the postoperative period varied). Therefore, the structural integrity that we achieved might not match the clinical outcomes at the final follow-up.

REFERENCES
1. Fukuda H. The management of partial-thickness tears of the rotator cuff. J Bone Joint Surg Br 2003;85:3-11.
2. Itoi E, Tabata S. Incomplete rotator cuff tears. Results of operative treatment. Clin Orthop Relat Res 1992;284:128-35.
3. Wright SA, Cofield RH. Management of partial-thickness rotator cuff tears. J Shoulder Elbow Surg 1996;5:458-66.
4. Lo IK, Gonzalez DM, Burkhart SS. The bubble sign: An arthroscopic indicator of an intratendinous rotator cuff tear. Arthroscopy 2002;18:1029-33.
5. Uchiyama Y, Hamada K, Khruekarnchana P, Handa A, Nakajima T, Shimpuku E, et al. Surgical treatment of confirmed intratendinous rotator cuff tears: Retrospective analysis after an average of eight years of follow-up. J Shoulder Elbow Surg 2010;19:837-46.
6. Fukuda H, Hamada K, Nakajima T, Tornonaga A. Pathology and pathogenesis of the intratendinous tearing of the rotator cuff viewed from in bloc histologic sections. Clin Orthop Relat Res 1994;304:60-7.
7. Ellman H, Hanker G, Bayer M. Repair of the rotator cuff. End-result study of factors influencing reconstruction. J Bone Joint Surg Am 1986;68:1136-44.
8. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 1987;214:160-4.
9. Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: Single-row versus dual-row fixation. Arthroscopy 2005;21:1307-16.
10. Teeffey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am 2004;86-A: 708-16.
11. Andarawis-Puri N, Ricchetti ET, Soslowsky LJ. Rotator cuff tendon strain correlates with tear propagation. J Biomech 2009;42:158-63.
12. Reilly P, Amis AA, Wallace AL, Emery RJ. Supraspinatus tears: Propagation and strain alteration. J Shoulder Elbow Surg 2003;12:134-8.
13. Deutsch A. Arthroscopic repair of partial-thickness tears of the rotator cuff. J Shoulder Elbow Surg 2007;16:193-201.
14. Kim KC, Shin HD, Cha SM, Park JY. Repair integrity and functional outcome after arthroscopic conversion to a full-thickness rotator cuff tear: Articular-versus bursal-side partial tears. Am J Sports Med 2014;42:451-6.
15. Kim SJ, Kim SH, Lim SH, Chun YM. Use of magnetic resonance arthrography to compare clinical features and structural integrity after arthroscopic repair of bursal versus articular side partial-thickness rotator cuff tears. Am J Sports Med 2013;41:2041-7.
16. Koh KH, Shon MS, Lim TK, Yoo JC. Clinical and magnetic resonance imaging results of arthroscopic full-layer repair of bursal-side partial-thickness rotator cuff tears. Am J Sports Med 2011;39:1660-7.
17. Wolff AB, Magit DP, Miller SR, Wyman J, Sethi PM. Arthroscopic fixation of bursal-side rotator cuff tears. Arthroscopy 2006;22:1247.e1-4.
18. Oh JH, Oh CH, Kim SH, Kim JH, Yoon JP, Jung JH. Clinical features of partial anterior bursal-sided supraspinatus tendon (PABST) lesions. J Shoulder Elbow Surg 2012;21:295-303.
19. Galotta LV, Nho SJ, Dodson CC, Adler RS, Altchek DW, MacGillivray JD, et al. Prospective evaluation of arthroscopic rotator cuff repairs at 5 years: Part 1 – functional outcomes and radiographic healing rates. J Shoulder Elbow Surg 2011;20:934-40.
20. Boughebri O, Roussignol X, Delattre O, Kany J, Valenti P. Small supraspinatus tears repaired by arthroscopy: Are clinical results influenced by the integrity of the cuff after two years? Functional and anatomic results of forty-six consecutive cases. J Shoulder Elbow Surg 2012;21:699-706.