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A retrospective study on the pathology and short-term outcomes of arthroscopic repair for intratendinous, bursal-side, and articular-side tears: comparison after conversion to full-thickness tears

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ABSTRACT

Partial-thickness rotator cuff tears (PTRCTs) are classified into intratendinous tears (ITT), bursal-side tears (BST), and articular-side tears (AST). ITT is relatively rare, and many aspects of its clinical presentation remain unknown. Moreover, there are few reports on arthroscopic rotator cuff repair (ARCR) of ITTs. To the best of our knowledge, few reports have compared the treatment outcomes of ARCR with those of BST, AST, and ITT. Patients who were diagnosed with ITT based on intraoperative findings and who could be followed up for at least 1 year postoperatively were included in this study. In all patients with PTRCTs, a complete tear was created and repaired via suture bridge techniques. Among the ITT, BST, and AST groups, the frequency of PTRCTs (ITT, BST, AST), patient background (age, sex, history of trauma), acromiohumeral distance (AHD), critical shoulder angle (CSA), lateral acromial angle (LAA), acromial morphology, Japanese Orthopaedic Association (JOA) score, and re-tear rate were compared. Fifteen patients underwent ARCR on ITT, 95 patients underwent BST, and 39 patients underwent AST. There were no significant differences in age, sex, or frequency of traumatic rotator cuff tears. The preoperative CSA showed significant differences; however, no significant differences were observed among the three groups for AHD, LAA, and acromion morphology. There were no significant differences in operation time, JOA score, or re-tear rate. The results of ARCR for ITT were good and may be a viable option for patients resistant to conservative treatment.

Keywords: intratendinous partial-thickness rotator cuff tears, bursal partial-thickness rotator cuff tears, articular partial-thickness rotator cuff tears

Abbreviations:
PTRCTs: partial-thickness rotator cuff tears
ITT: intratendinous tears
BST: bursal-side tears
AST: articular-side tears
ARCR: arthroscopic rotator cuff repair
CSA: critical shoulder angle

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LAA: lateral acromial angle
MRI: magnetic resonance imaging

INTRODUCTION

Rotator cuff tears are a common cause of shoulder pain and movement problems[1] and can occur in athletes and older people. Among these tears, partial-thickness rotator cuff tears (PTRCTs) are a type in which the tendon is not completely torn.[2] PTRCTs are divided into three types according to the location of the tear: intratendinous tears (ITT; Fig. 1), bursal-side tears (BST; Fig. 2), and articular-side tears (AST; Fig. 3). Each type of tear poses different problems and requires specialized diagnosis and treatment.[3] However, ITTs are still not well understood, and more research is needed to elucidate the pathophysiology and management of the injury. ITT

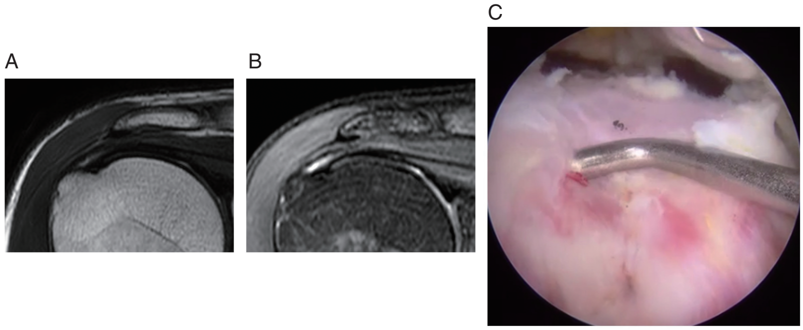

Fig. 1 Intratendinous tears (ITT)
(A) MRI T2WI, (B) T2 fat-suppressed MRI, and (C) arthroscopic findings.
MRI: magnetic resonance imaging
T2WI: T2 weighted image

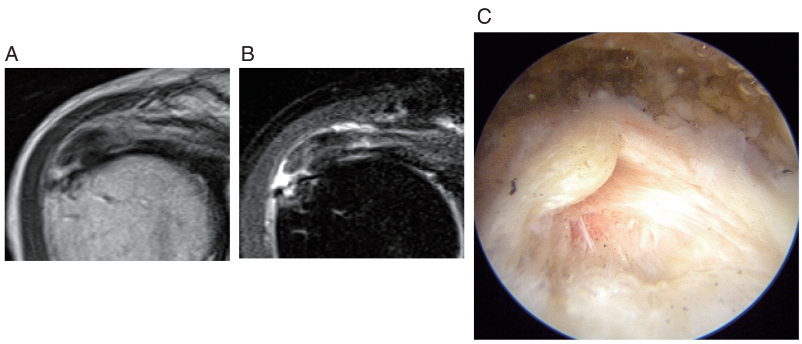

Fig. 2 Bursal-side tears (BST)
(A) MRI T2WI, (B) T2 fat-suppressed MRI, and (C) arthroscopic findings.
MRI: magnetic resonance imaging
T2WI: T2 weighted image

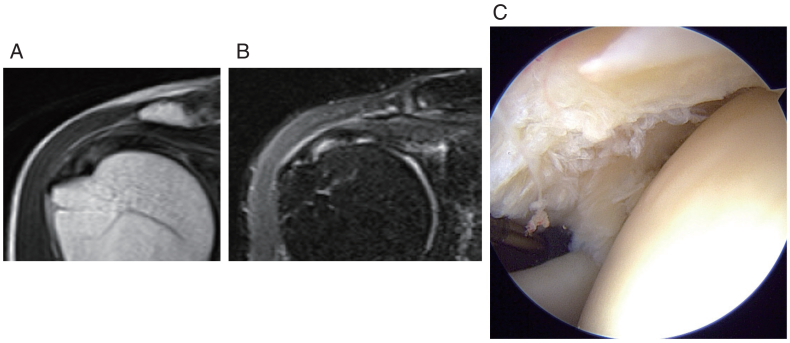

Fig. 3 Articular-sided tears (AST)
(A) MRI T2WI, (B) T2 fat-suppressed MRI, and (C) arthroscopic findings.
MRI: magnetic resonance imaging
T2WI: T2 weighted image

is less common than AST and BST, but better imaging and surgical tools have made it easier to identify the disease.[4] BST occurs on the outer side of the tendon near the bursa, and AST occurs on the inner side near the joint.[3] In the past, diagnosis was difficult due to limitations in imaging and surgical techniques. In recent years, high-quality magnetic resonance imaging (MRI), ultrasound, and better arthroscopic tools allow us to see and understand these tears more clearly.[5,6]

The critical shoulder angle (CSA) and low lateral acromion angle are known to be involved in the pathogenesis of full-thickness rotator cuff tears; however, their relationship with PTRCTs remains unclear.[7] Additionally, acromial morphology, as evaluated by the Bigliani classification, has shown that the type 3 acromion is associated with BSTs, indicating its potential role in influencing the development of specific tear types.[8] However, further studies are needed to understand whether these anatomical factors contribute to the development of PTRCTs.

Advances in arthroscopic rotator cuff repair (ARCR) have greatly improved how PTRCTs are treated.[9] Techniques such as transtendinous repair, in situ repair, and the use of biological scaffolds have shown good results in fixing the tendon and helping the shoulder work again.[10-12] ARCR is less invasive, which means that patients experience less pain after surgery and can start rehabilitation sooner. This allows them to return to daily activities and sports faster.

Learning more about the injury mechanism of PTRCTs has also helped surgeons decide how to treat them. By considering the patient’s age, activity level, depth of the tear, and other health problems when planning treatment, clinicians may be able to tailor their treatment strategies to the specific type of tear. However, the mechanism of PTRCTs is still unclear and difficult to determine. Studies have shown that ARCR yields better results and greater patient satisfaction than non-surgical treatments, especially for tears that cause symptoms and do not improve with other methods. Recent studies have shown that surgery for PTRCTs can reduce pain, improve movement, and make patients feel better overall.[9] MRI and surgical tools have also helped surgeons better understand ITT, which used to be harder to diagnose and treat.[13]

In this study, we hypothesized that the surgical outcomes for ITTs will be comparable to those for BSTs and ASTs. To the best of our knowledge, few reports have compared the treatment outcomes of ARCR among different types of PTRCTs, including BST, AST, and ITT. This study aims to compare the clinical pathology and treatment outcomes of ARCR for ITT with those of BST and AST. By understanding these differences, we hope to identify the best strategies for effectively managing PTRCTs and improving patient outcomes.

METHODS

Patient selection

We retrospectively reviewed a database of all ARCRs performed by a single surgeon between 2016 and 2023. A total of 651 patients who underwent ARCR were included. The surgical indications were patients who were resistant to conservative treatment for more than six months.

The inclusion criteria for this study were the presence of a rotator cuff tear, including the supraspinatus tendon, and preoperative imaging evaluation with both X-rays and MRI. Patients who met these criteria were included for further analysis.

The exclusion criteria were revision surgery, a history of fractures involving the scapula, humerus, or clavicle, the presence of shoulder osteoarthritis, and cases where PTRCTs were identified arthroscopically but the tear depth was mild (less than 50% of the greater tuberosity footprint) and did not require repair.

Surgeries were carried out under general anesthesia with the addition of an interscalene nerve block. Patients were placed in the beach chair position. For patients with preoperative shoulder joint contracture, arthroscopic pan-capsular release was performed. Additionally, subacromial decompression was carried out for those with subacromial spurs. In all patients, BST, AST, and ITT were intraoperatively confirmed. In our study, ITT were confirmed when tendon delamination or intrasubstance degeneration was evident upon probing and debridement, despite an intact bursal and articular surface.

In all cases, PTRCTs were treated by converting them into full-thickness tears. To do this, the remaining fibers at the greater tuberosity footprint were carefully separated via a radiofrequency device, creating a complete tear. This was then repaired via the suture-bridge technique (Fig. 4). Medial anchors (Healix; DePuy-Mitek, Raynham, MA) were placed near the cartilage edge of the humeral head. Sutures from these anchors were passed through the tendon. Lateral anchors (Quatro Link knotless; Zimmer Biomet, Warsaw, IN) were positioned approximately 5 mm below

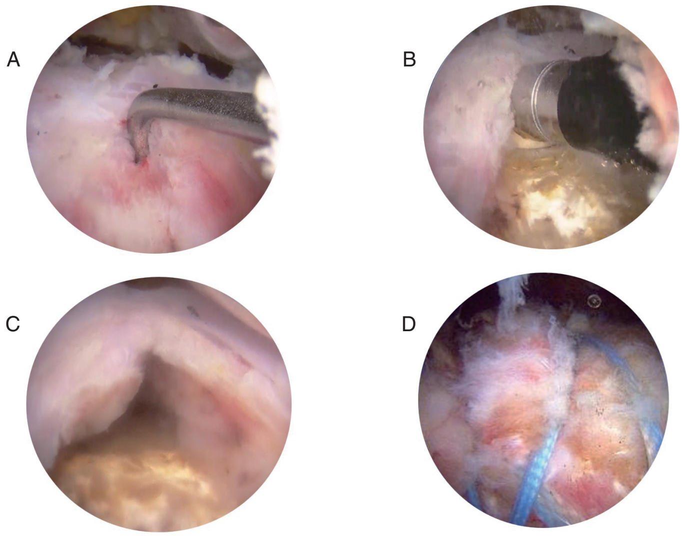

Fig. 4 Intratendinous tears (ITT) is treated by converting it into a full-thickness tear
A, Arthroscopic view of the bursal side. B, Intact fibers at the greater tuberosity footprint are separated via a radiofrequency device. C, This creates a complete tear. D, The ITT is repaired via the suture-bridge technique.

the outer edge of the greater tuberosity to complete the repair.

This study adhered to the Declaration of Helsinki and was approved by the ethics committee at Ichinomiya Nishi Hospital. Informed consent was obtained from all patients for the research. (approval number, 2024081)

Postoperative protocol

All patients adhered to a standardized rehabilitation protocol. The shoulder was immobilized via a sling and abduction pillow for 4 weeks. Range of motion exercises for the elbow, wrist, and fingers commenced immediately after surgery. Passive forward elevation exercises were initiated on the first postoperative day. Active-assisted motion exercises began at 4 weeks postoperatively, followed by active motion exercises at 6 weeks, and a strengthening exercise program was introduced at 8 weeks postoperatively.

Evaluation criteria

Among the ITT, BST, and AST groups, the frequency of PTRCTs (ITT, BST, AST), patient background (age, sex, history of trauma), acromiohumeral distance (AHD), CSA, lateral acromial angle (LAA), acromial morphology, Japanese Orthopaedic Association (JOA) score, and re-tear rate were compared. Traumatic tears were defined as tears without shoulder pain prior to trauma and with the onset of acute shoulder pain after trauma.

The AHD was previously defined by Ellman et al.[3] The CSA was defined as the angle between a line connecting the superior and inferior edges of the glenoid fossa and another line connecting the inferior edge of the glenoid with the most inferolateral edge of the acromion.[7] The LAA was defined as the intersection of two lines representing the glenoid cavity and the inferior surface of the acromion.[8] Standard anteroposterior radiographs were used to measure the AHD, CSA, and LAA.

The sagittal acromial morphology was classified according to a method described by Bigliani et al.[14] Assessments were made on scapular Y radiographs and classified as either Type 1 (flat), Type 2 (curve), or Type 3 (hook) acromia. These findings were evaluated by a single orthopedic surgeon who specializes in shoulder surgery.

MRI examination

MRI scans were conducted via a 3-tesla closed-type scanner (MRT-2000/V2, Toshiba, Tokyo, Japan). The structural integrity of the repairs was assessed using oblique coronal, oblique sagittal, and axial T2-weighted images. MRI evaluations were performed preoperatively and at 6, and 12 months postoperatively. Repair integrity was classified according to the 5-category Sugaya classification system.[15] Postoperative retears were identified as those falling under Sugaya Type IV or Type V.

Statistical analysis

Continuous data were given as mean ± standard deviation (SD). Categorical and ordinal data were presented as numbers and percentages. For comparisons among the three groups, one-way analysis of variance (ANOVA) was used for continuous data, and Fisher's exact test was used for categorical data. For comparison between two groups, unpaired t-test was used for continuous data and Fisher's exact test for categorical data. *P* values were corrected by the Bonferroni method to avoid multiplicity of tests. For within-group comparisons, paired t-test was used for continuous data and Wilcoxon signed-rank test for ordinal data. All statistical analyses were performed with SPSS version 29.0.2.0 for Windows (IBM Japan, Tokyo, Japan). A *p*-value of ≤ 0.05 was considered statistically significant.

RESULTS

This study analyzed 15 cases of ITT, 95 cases of BST, and 39 cases of AST. The patient characteristics, surgical data, and clinical outcomes are summarized below.

Among those in the ITT group, the mean patient age was 59.8 ± 11.2 years (SD), with 5 male and 10 female patients. In the BST group, the mean age was 59.2 ± 8.6 years (SD), comprising 49 male and 46 female patients. The AST group had a mean age of 60.1 ± 8.8 years (SD), with 20 male and 19 female patients. A history of trauma was identified in some patients across all groups (Table 1).

Table 1 Patient demographics

	ITT	**BST**	**AST**	***P* value**
Number of patients	15	95	39	
Age (years)	59.8±11.2	59.2±8.6	60.1±8.8	0.86
Sex (male/female)	5/10	49/46	20/19	0.46
Traumatic tear	7 (46.7%)	33 (34.7%)	10 (25.6%)	0.33

AST: articular-side tears
BST: bursal-side tears
ITT: intratendinous tears

Preoperative evaluation revealed significant differences in CSA among the groups, whereas no significant differences were observed in LAA, AHD, or acromial morphology (Table 2).

Table 2 Results of the CSA, LAA, AHD, and acromial morphology

	ITT	**BST**	**AST**	***P* value**
CSA (°)	33.0±4.7	35.3±4.4	32.1±4.6	0.001
LAA (°)	83.1±6.5	79.9±7.0	82.2±7.2	0.10
AHD (mm)	9.8±1.7	9.3±1.4	9.4±1.5	0.47
Bigliani classification (Type1/2/3)	10/5/0	32/43/20	16/21/2	0.19

AHD: acromiohumeral distance
AST: articular-side tears
BST: bursal-side tears
CSA: critical shoulder angle
ITT: intratendinous tears
LAA: lateral acromial angle

The operation times slightly varied, averaging 85.7±15.0 minutes (SD) for the ITT group, 92.1±18.5 minutes (SD) for the BST group, and 91.7±21.3 minutes (SD) for the AST group. There were no significant differences in operation time among the groups.

Postoperative outcomes revealed that JOA scores improved significantly in all groups. In the ITT group, the scores improved from 65.3±14.1 points (SD) preoperatively to 93.0±6.8 points (SD) postoperatively. The BST group improved from 64.4±13.4 points (SD) to 95.0±7.7 points (SD), and the AST group improved from 63.6±12.5 points (SD) to 95.0±9.2 points (SD). There were no significant differences in the improvement in JOA scores among the three groups.

The re-tear rates were low across all the groups. The ITT group had no re-tears (0%), the BST group had a re-tear rate of 2.1%, and the AST group had a re-tear rate of 2.6%. No significant differences in re-tear rates were observed among the groups (Table 3).

Table 3 Results of Sugaya classification

	ITT	BST	AST
Type I	12	62	26
Type II	2	28	11
Type III	1	3	1
Type IV	0	0	1
Type V	0	2	0

AST: articular-side tears
BST: bursal-side tears
ITT: intratendinous tears

DISCUSSION

The pathogenesis of ITT remains unclear, though various hypotheses suggest that intrinsic tendon degeneration, overuse, and microtrauma might play a role in the development of these conditions.[16-18] Unlike BST and AST, ITT occurs within the tendon itself, making it more challenging to detect and treat. The relatively low frequency of ITT compared with BST and AST further complicates our understanding of its pathogenesis.

In clinical practice, ITTs are typically managed with conservative treatments such as physical therapy, anti-inflammatory medications, and activity modifications. However, in cases where symptoms persist despite prolonged conservative therapy, surgical intervention becomes necessary. ARCR has emerged as a viable treatment option for refractory patients. The findings of this study, which demonstrate favorable outcomes of ARCR for ITT, support its utility in addressing challenging cases of ITT.

Previous reports on ARCR outcomes for ITT are limited, but the available studies indicate that surgical repair can provide significant symptom relief and functional improvement. Kim et al[13] demonstrated that ARCR for ITT yielded significant improvements in shoulder function and low re-tear rates, reinforcing its efficacy as a treatment option. Similarly, Xiao et al[19] demonstrated that the clinical and MRI outcomes of ARCR for ITT were satisfactory, with notable improvements in structural integrity and patient-reported outcomes. Cheon et al[20] further confirmed the reliability of the ARCR for ITT, reporting stable clinical results and high patient satisfaction rates. Donohue et al[9] examined the functional outcomes of ARCR for high-grade partial-thickness tears, including ITT, and reported that ARCR achieved significant improvements in shoulder function and pain relief across tear types. These studies collectively highlight the consistent effectiveness of ARCR for ITT. In our study, patients with ITT showed clinical outcomes comparable to those with BST and AST, suggesting that ARCR is an effective option for ITT. This aligns with the growing evidence that advancements in surgical techniques, such as suture-bridge repairs, have improved outcomes across various types of PTRCTs.

For the surgical approach to ITT, two main techniques are used: conversion to full-thickness tears followed by repair and in-situ repair of the partial tear. Previous studies have shown that both methods result in low re-tear rates and stable surgical outcomes. Xiao et al[19] reported that ARCR for ITT provided satisfactory clinical and MRI results, indicating improved structural integrity and patient outcomes. They repaired ITTs as BSTs using a single-row repair. Kim et al[13] demonstrated significant functional improvements and low re-tear rates following ARCR for ITT, repairing ITTs by converting it to full-thickness tears and using either single-row or suture-bridge techniques. Additionally, Cheon et al[20] confirmed that ARCR yields stable outcomes and high satisfaction for ITT patients, converting ITTs to full-thickness tears and employing suture-bridge repair. While it remains unclear which method is superior for ITT repair, both techniques have demonstrated favorable results. The choice of repair method ultimately depends on the surgeon's expertise and preference.

In the case of BST and AST, numerous studies have reported excellent surgical outcomes with ARCR.[21-23] These tears are more commonly encountered, and the surgical strategies for their repair are well-established. BST, which occurs on the bursal side of the tendon, has been linked to mechanical irritation by the acromion. Acromial morphology, particularly the Bigliani type 3 acromion, has been associated with the development of BST.[24,25] Meanwhile, AST, located on the articular side, is often attributed to tensile stress during shoulder movements.[26] Despite these differences in etiology, ARCR for both BST and AST have shown low re-tear rates and significant improvements.[21-23]

Our study also highlights the importance of anatomical factors such as the CSA and LAA in the pathogenesis of rotator cuff tears. While these factors are well-documented in full-thickness rotator cuff tears, their role in PTRCTs remains uncertain.[27] In this study, preoperative CSA differed significantly among groups, but the LAA and acromial morphology did not significantly differ, suggesting that these factors may influence tear type.

To the best of our knowledge, few reports have compared the treatment outcomes of ARCR with those of BST, AST, and ITT.[9] We hypothesized that ARCR for ITT may provide outcomes comparable to those for BST and AST due to the application of advanced arthroscopic techniques. This study aimed to compare the clinical features and outcomes of ARCR for ITT with those of BST and AST, providing insights into the management of PTRCTs.

This study has several limitations. First, it is a retrospective analysis conducted at a single institution, which may limit how well the results apply to other settings. Second, the sample size for the ITT group was smaller than those for the BST and AST groups, which could affect the reliability of the comparisons. Lastly, the follow-up period was only one year after surgery, so long-term results such as functional decline or re-tear rates were not examined.

CONCLUSION

This study revealed that the outcomes of ARCR for ITT are favorable, with good improvements in shoulder function and low re-tear rates. These results suggest that ARCR is a suitable option for ITT patients who do not respond to conservative treatment. Further research is needed to clarify the pathogenesis of ITT and optimize its surgical management.

CONFLICTS OF INTEREST STATEMENT

None.

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