

Original article

Arthroscopic repair for subacromial incarceration of a torn rotator cuff

Hiroyuki Nakamizo*

Kagawaken Saiseikai Hospital, 1331-1 Tahikami-machi, Takamatsu-city, Kagawa 7618076, Japan

Received 25 December 2014; revised 26 February 2015; accepted 2 April 2015

Available online 7 May 2015

Abstract

Background/objective: Rotator cuff tears are common shoulder injuries. Various forms of rotator cuff tears are observed by arthroscopy. Inverted flap tears of the rotator cuff, however, also occur. The aim of the present study was to determine the preoperative characteristics of inverted torn cuffs and clinical outcomes after arthroscopic repair.

Methods: Seventeen patients (10 men, 7 women; mean age, 65.8 years; age range, 41–80 years) who underwent arthroscopic rotator cuff repair for an inverted flap tear participated in the study. The mean follow-up period was 31.8 months (range, 24–61 months). The preoperative history, radiographs, magnetic resonance images, tear pattern of the rotator cuff, preoperative and postoperative University of California Los Angeles (UCLA) rating scale, and postoperative repair integrity were assessed.

Results: Only two patients had acute episodes of aggravated shoulder pain. In radiographs, the anteroposterior view revealed a heel-type acromion in 8/17 (47.1%) patients with an inverted flap tear compared with 27/345 (7.8%) patients with ordinary retracted tears ($p < 0.001$). The supraspinatus tendon was incarcerated in all cases. The UCLA score increased from 11.9 ± 2.7 points to 32.5 ± 2.1 points postoperatively ($p = 0.002$). Postoperative magnetic resonance images at 12 months after surgery showed good repair integrity in all cases.

Conclusion: Arthroscopic reduction and repair are applicable for inverted flap tears of the rotator cuff. The findings of the present study indicated that patients with a heel-type acromion in the anteroposterior view of radiographs are at greater risk for inverted flap tears of the rotator cuff. Copyright © 2015, Asia Pacific Knee, Arthroscopy and Sports Medicine Society. Published by Elsevier (Singapore) Pte Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Keywords: arthroscopy; inverted flap tear; rotator cuff tear; subacromial incarceration

Introduction

Rotator cuff tears are very common shoulder injuries. Patients with rotator cuff tears frequently complain of shoulder pain and dysfunction. Therefore, the main treatment goals for rotator cuff tears are pain reduction and recovery from dysfunction. Arthroscopic rotator cuff repair is a very useful procedure for reattaching torn cuffs and can result in reasonable functional and structural outcomes.^{1–4} In most cases, the torn rotator cuffs are retracted proximally, so they are pulled distally and fixed on the footprint with various techniques. Various

forms of torn cuffs are observed during surgery. In arthroscopy, the torn cuff is sometimes observed as a flap. The flap-like torn rotator cuff can be inverted toward the bursal side and incarcerated under the acromion. Patients with inverted flap tears experience severe pain due to subacromial impingement of the torn cuff. There are very few reports regarding the incarceration of torn rotator cuffs.⁵ We have observed a hooked shape (like a shoe “heel”) acromion in the coronal plane in some patients with an inverted flap tear. Oh et al⁶ suggested that a “heel-type” acromion is a risk factor for rotator cuff tears. It is important to evaluate how the inverted flap tear of a rotator cuff occurs. The purpose of the present study was to investigate the preoperative characteristics and clinical outcomes after arthroscopic repair of inverted flap tears of the rotator cuff.

* Kagawaken Saiseikai Hospital, 1331-1 Tahikami-machi, Takamatsu-city, Kagawa 7618076, Japan.

E-mail address: hnakamizo@saiseikai-kagawa.jp.

Methods

From September 2007 to August 2012, 362 consecutive shoulders in 340 patients with an isolated supraspinatus tendon tear or both supraspinatus and infraspinatus tendon tears underwent primary arthroscopic rotator cuff repair by a single surgeon (H.N.). An inverted flap tear of the rotator cuff was detected in 18 shoulders of 18 patients (5.0%). Among them, one patient moved away within 12 months after surgery, and therefore the data for 17 shoulders in 17 patients were analysed. Study participants were 10 men and 7 women with a mean age of 65.8 years (range, 41–80 years) at the time of surgery. The mean follow-up was 31.8 months (range, 24–61 months). Based on the arthroscopic findings, 11 patients had full-thickness tears and six had Grade 3 partial-thickness bursal-sided tears based on the classification system described by Ellman⁷ (Table 1): Grade 1 (< 3 mm deep), Grade 2 (3–6 mm deep), and Grade 3 (> 6 mm deep).

All patients underwent arthroscopy in the beach chair position with general anaesthesia. Normal pump pressure was set at 50 mmHg. After arthroscopic examination of the glenohumeral joint and subacromial space, arthroscopic subacromial decompression was routinely performed to create a flat acromial undersurface.⁸ The inverted torn rotator cuff could be seen within the supraspinatus tendon and was reducible using a probe or a grasper in all patients. The reduced torn cuff was fixed to the footprint of the greater tuberosity with a dual-row technique for full-thickness tears, or a single-row technique without converting to a full-thickness tear⁹ for bursal-sided tears (Fig. 1). After the procedure, the affected shoulder was immobilised for 4 weeks using an abduction pillow. Passive motion exercise was started within 1 week after surgery. Active-assistive elevation exercise was initiated after the immobilisation period. Rotator cuff strengthening exercises were started 12 weeks after surgery.

Patient assessment

When obtaining the medical history, each patient was asked whether he or she had an acute episode of aggravated shoulder pain. After a standard history and physical examination, the patients underwent imaging studies, including radiographs of the anteroposterior view in both internal and external rotation and supraspinatus outlet views, and preoperative magnetic resonance imaging (MRI) on the affected side. In some cases, the inverted flap tear of the rotator cuff was revealed in an oblique coronal view (Fig. 2), but the tear size and pattern were determined during diagnostic arthroscopy. Based on the preoperative radiographs, the morphology of the acromion was classified into three types (Type I–III) in the supraspinatus outlet view according to the Bigliani classification,¹⁰ and into two types (heel-type or not) in the anteroposterior view in external rotation and in the oblique coronal view of MRI (Fig. 3). Moreover, the lateral acromial angle (LAA) was measured in the oblique coronal view of T2-weighted MR images as described by Banas et al.¹¹ The LAA was defined as the slope of the inferior surface of the acromion (relative to the glenoid face).

All patients were evaluated preoperatively and at the final follow-up postoperatively using the rating scale of the University of California Los Angeles (UCLA), Los Angeles, CA, USA). Postoperative MRI in all patients was obtained 12 months after surgery and cuff integrity was classified into five types (Type I–V) according to Sugaya et al.³

A Chi-square analysis was used to compare the differences between patients with a heel-type acromion among the other patients with inverted flap tears and among the 284 cases of retracted tears. The Wilcoxon's signed ranks test was used to compare the preoperative and postoperative scores of the UCLA rating scale. A *p* level of 0.05 was considered statistically significant.

Table 1
Patients' information.

Case (no.)	Age (y)	Sex	Acute episode of aggravated pain	Tear pattern	Incarcerated tendon	Repair	Acromion shape (Bigliani)	Heel-type acromion (Oh et al ⁶)
1	55	M	None	Bursal	SSP	Single	I	Yes
2	50	M	Fall	Complete	SSP	Double	I	Yes
3	75	F	None	Bursal	SSP	Single	I	Yes
4	60	F	None	Bursal	SSP	Single	II	No
5	41	M	None	Complete	SSP	Double	II	No
6	72	F	None	Complete	SSP	Double	II	No
7	69	M	None	Bursal	SSP	Single	II	No
8	65	F	None	Complete	SSP	Double	II	Yes
9	72	M	None	Bursal	SSP	Single	I	Yes
10	77	M	None	Complete	SSP	Double	III	No
11	61	M	None	Bursal	SSP	Single	I	No
12	74	M	Fall	Complete	SSP	Double	I	Yes
13	69	F	None	Complete	SSP	Double	I	No
14	58	F	None	Complete	SSP	Double	II	No
15	69	F	None	Complete	SSP	Double	I	Yes
16	80	M	None	Complete	SSP	Double	I	Yes
17	71	M	None	Complete	SSP	Double	II	Yes

F = female; M = male; SSP = supraspinatus.

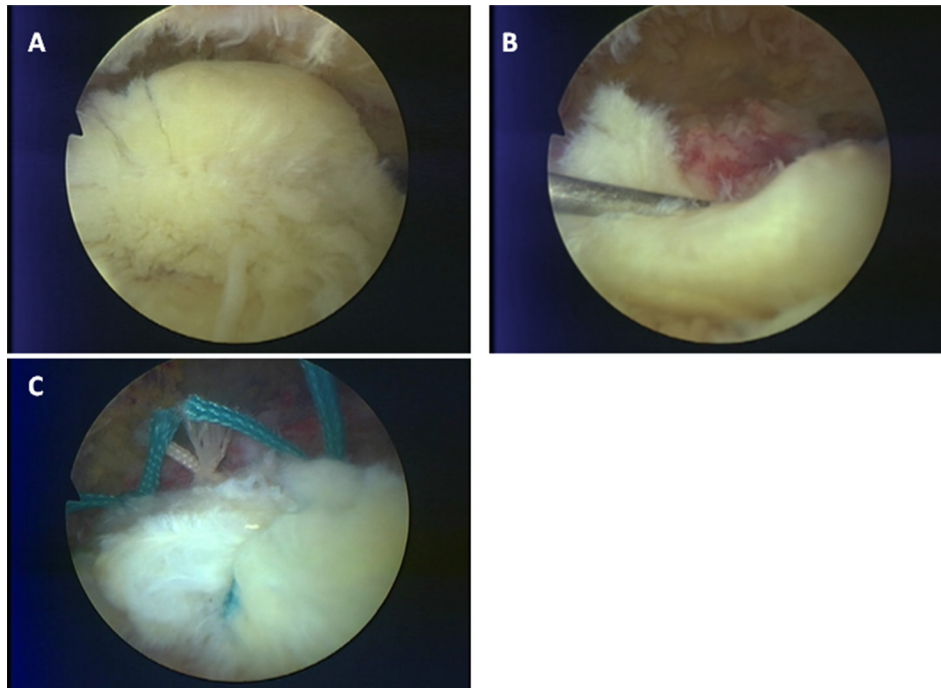


Fig. 1. Arthroscopic findings for subacromial incarcerated torn rotator cuffs (right shoulder). (A) Inverted tear of the supraspinatus tendon; (B) reduction using a probe; and (C) postoperative finding.

Results

Patient profiles are shown in Table 1. Of the 17 patients, 15 reported no acute episode that aggravated their shoulder pain. Two patients reported an acute episode due to a fall onto the ground. The inverted flap tear was found in the supraspinatus tendon in all cases.



Fig. 2. Preoperative magnetic resonance imaging. Inverted flap tear of the supraspinatus tendon is shown in the oblique coronal view (arrow).

In radiographs of the supraspinatus outlet view, there were nine Type I, seven Type II, and one Type III acromions in those with inverted flap tears, and 153 Type I, 176 Type 2, and 16 Type III acromions in those with ordinary tears. There was no statistical difference between the two groups. By contrast, in radiographs of the anteroposterior view and MRI, there were eight (47.1%) heel-type acromions among those with inverted flap tears and 27 (7.8%) among those with ordinary retracted tears. The difference between the two groups was significant ($p < 0.001$).

The LAA was $73.6 \pm 4.5^\circ$ (range, 70° – 81°) among those with inverted flap tears, and $78.9 \pm 4.2^\circ$ (range, 70° – 88°) among those with retracted tears. There was no significant difference between the two groups.

The mean total score of the UCLA rating scale increased from 12.0 ± 2.6 points (range 8–17 points) preoperatively to 32.6 ± 2.2 points (range 30–35 points) postoperatively ($p = 0.002$). All patients had good or excellent outcomes.

Postoperative MRI of the cuff integrity showed 13 Type I and four Type II according to Sugaya's classification. The cuffs in all cases were repaired without discontinuity.

Discussion

There are several reports of successful clinical and structural outcomes after arthroscopic rotator cuff repair. In almost all cases, torn rotator cuffs are retracted proximally. Thus, the main goals of surgery are to pull torn cuffs distally and fix them to the footprint using various techniques (i.e., single row, double row, and suture bridging).

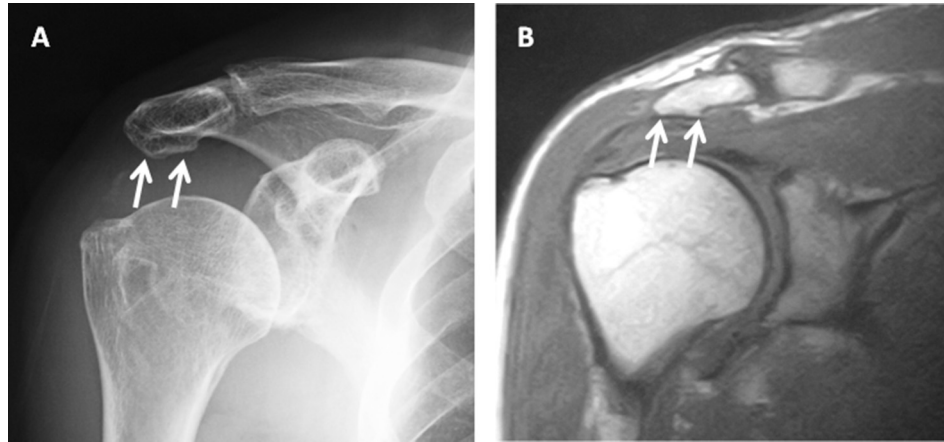


Fig. 3. (A) X-ray and (B) magnetic resonance imaging showing the heel-type acromion.

A flap-like torn rotator cuff is sometimes seen during surgery. Inverted flap tears of the rotator cuff, however, are not common. Dodson et al⁵ reported an unusual case of a young patient whose torn cuffs were incarcerated in the glenohumeral joint. There are some reports of interposed rotator cuffs in the glenohumeral joint.^{12–15} Most of them had sequelae of shoulder dislocation, which resulted in persistent subluxation after a closed reduction manoeuvre. Rotator cuffs were avulsed during trauma and interposed in the glenohumeral joint in previously reported cases. By contrast, 15/17 cases in the present study were not associated with a trauma. To our knowledge, there are no reports of inverted flap tears of the rotator cuff in the literature.

How do inverted flap tears of the rotator cuff occur? Initially, mechanical impingement of the rotator cuff beneath the acromion was thought to be the main cause. Rotator cuff tears lead to muscle imbalance in the shoulder, which causes humeral head translation superiorly. This mechanism can cause subacromial impingement of the torn cuff. It was speculated that inverted flap tears in most cases occur due to repetitive subacromial impingement. The mechanism for the two patients in the present study who had an acute episode that aggravated their pain, however, would likely be different. In these cases, during a fall onto the ground with a slightly abducted shoulder, axial load was applied along the humerus and the rotator cuff was torn due to a crush between the acromion and greater tuberosity. The torn rotator cuff thus inverted when the abducted shoulder moved downward.

Bigliani et al¹⁰ reported that acromions with a hooked shape in the sagittal plane have a higher incidence of rotator cuff tears. Our study showed that the ratio of Type I–III acromions in the inverted flap tear group did not differ significantly from that in the normal tear group. In the anteroposterior radiographic view, however, 47.1% of patients with an inverted flap tear had a heel-type acromion, higher than the percentage of patients with retracted tears and heel-type acromions. Oh et al⁶ reported that heel-type acromions were associated with rotator cuff tears. They investigated 142 acromion spurs. The heel-type acromion was detected in 56% of patients with cuff tears. Hirano et al¹⁶ reported that the

hook-type acromion in the supraspinatus outlet view is not associated with rotator cuff injuries. The present findings indicated that the hook-type acromion was related to inverted flap tears of the rotator cuff. Banas et al¹¹ reported that LAA in the oblique coronal view of MRI was related to rotator cuff tears. They described a significant increase in rotator cuff injury with a decrease in the LAA. They also demonstrated that the rotator cuff score increased if the LAA was $< 75^\circ$. The reports of Hirano et al¹⁶ and Banas et al¹¹ indicated that rotator cuff tears are associated with the shape of the acromion in both the coronal view and the supraspinatus outlet view. In the present study, the LAA in patients with inverted flap tears of the rotator cuff was 73.6° , and it was not significantly different from that in patients with retracted tears. A low LAA, however, is a risk factor for rotator cuff tears according to Banas et al.¹¹ We suspect that a low LAA is a risk of impingement between the acromion and rotator cuff and thus the flap-like torn cuff is easy to interpose and invert under the acromion.

All of the incarcerated cuffs in the present study could be repaired using arthroscopic techniques. The inverted torn cuffs were not too retracted to repair arthroscopically, and could be reduced and fixed on the greater tuberosity. We recommend performing arthroscopic subacromial decompression during surgery. Arthroscopic subacromial decompression is reasonable for creating a flat undersurface to prevent postoperative subacromial impingement, and to create a working space to reduce the incarcerated cuff. Especially for patients with a heel-type shape acromion in the anteroposterior view on radiographs, arthroscopic subacromial decompression is a good option.

In cases of full-thickness tears, the double row technique or suture bridging technique is reasonable for repair. In cases of partial-thickness bursal-sided tears, we used a single-row technique without converting to a full-thickness tear, as described by Wolff et al.⁹ They performed arthroscopic fixation for Grade 2 and Grade 3 bursal-sided tears without converting to a full-thickness tear and achieved excellent clinical results. Cordasco et al¹⁷ reported a significantly higher overall failure rate for patients with bursal-sided tears than for patients with articular-sided tears with arthroscopic anterior

acromioplasty. Weber¹⁸ suggested that debridement is not adequate treatment for partial-thickness bursal-sided rotator cuff tears. The reports of Cordasco et al¹⁷ and Weber¹⁸ support the notion that arthroscopic anterior acromioplasty is a reasonable approach for repairing bursal-sided rotator cuff tears. In Wolff et al,⁹ all patients had Grade 3 bursal-sided tears with a good clinical outcome, indicating that a single-row technique is reasonable for repair.

The findings of the present study do not clarify the cause of inverted flap tears of the rotator cuff, but indicate that the heel-type acromion in the coronal plane and lower LAA are risk factors for subacromial impingement. Once the torn cuff is incarcerated under the acromion, it is difficult to reduce naturally. Arthroscopic rotator cuff repair is very useful for reducing the inverted cuff and fixing it on the footprint. The clinical results and postoperative MR images also supported its validity for repairing inverted flap tears of the rotator cuff.

The present study has some limitations. First, only a small number of patients participated in this study. Inverted flap tears of the rotator cuff, however, are less common than ordinary retracted tears. Second, in the anteroposterior view on radiographs, the posture of each patient might affect the view of the acromion. Moreover, it is difficult to precisely evaluate the shape of the acromion. Three-dimensional computed tomography may resolve this limitation.

Arthroscopic reduction and repair were applicable for the 17 patients with inverted flap tears of the rotator cuff. All patients had good or excellent results with functional and structural recovery. Patients with a heel-type acromion in the coronal plane are at greater risk for inverted flap tears.

Conflicts of interest

The author declares no conflicts of interest.

References

- Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of rotator cuff. *J Bone Joint Surg.* 1998;80-A:832–840.
- Tauro JC. Arthroscopic rotator cuff repair: analysis of technique and results at 2- and 3- year follow-up. *Arthroscopy.* 1998;14:45–51.
- 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;21:1307–1316.
- Frank JB, ElAttrache NS, Dines JS, Blackburn A, Crues J, Tibone JE. Repair site integrity after arthroscopic transosseous-equivalent suture-bridge rotator cuff repair. *Am J Sports Med.* 2008;36:1496–1503.
- Dodson CC, Bedi S, Sahai A, Potter HG, Cordasco FA. Complete rotator cuff tendon avulsion and glenohumeral joint incarceration in a young patient: a case report. *J Shoulder Elbow Surg.* 2010;19:e9–12. <http://dx.doi.org/10.1016/j.jse.2009.07.014>.
- Oh JH, Kim JY, Lee HK, Choi JA. Classification and clinical significance of acromial spur in rotator cuff tear. *Clin Orthop Relat Res.* 2010;468:1542–1550.
- Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. *Clin Orthop Relat Res.* 1990;254:64–74.
- Ellman H. Arthroscopic subacromial decompression: analysis of one- to three- year results. *Arthroscopy.* 1987;3:173–181.
- Wolff AB, Magit DP, Miller SR, Wyman J, Sethi PM. Arthroscopic fixation of bursal-sided rotator cuff tears. *Arthroscopy.* 2006;22:1247. e1–4.
- Bigliani LU, Morrison DS, Aoril EW. The morphology of the acromion and its relationship to rotator cuff tears. *Orthop Trans.* 1986;10:216.
- Banas MP, Miller RJ, Totterman S. Relationship between the lateral acromion angle and rotator cuff disease. *J Shoulder Elbow Surg.* 1995;4, 454–461.
- Tietjen R. Occult glenohumeral interposition of a torn rotator cuff. A case report. *J Bone Joint Surg Am.* 1982;64:458–459.
- Walch G, Boulahia A, Robinson AH, Calderone S. Posttraumatic subluxation of the glenohumeral joint caused by interposition of the rotator cuff. *J Shoulder Elbow Surg.* 2001;10:85–91.
- Connolly S, Ritchie D, Sinopidis C, Brownson P, Aniq H. Irreducible anterior dislocation of the shoulder due to soft tissue interposition of subscapularis tendon. *Skeletal Radiol.* 2008;37:63–65.
- Lin CL, Su WR, Jou IM, Chih WH. Occult interpositional rotator cuff- an extremely rare case of traumatic rotator cuff tear. *Korean J Radiol.* 2012;13:98–101.
- Hirano M, Ide J, Takagi K. Acromial shapes and extension of rotator cuff tears: magnetic resonance imaging evaluation. *J Shoulder Elbow Surg.* 2002;11:576–578.
- Cordasco FA, Backer M, Craig EV, Klein D, Warren RF. The partial-thickness rotator cuff tear: is acromioplasty without repair sufficient? *Am J Sports Med.* 2002;30:257–260.
- Weber SC. Arthroscopic debridement and acromioplasty versus mini-open repair in the treatment of significant partial-thickness rotator cuff tears. *Arthroscopy.* 1999;15:126–131.