

# Technique for Arthroscopic Resection of the Distal Clavicle in Patients with Symptomatic Acromioclavicular Joint Osteoarthritis: A Retrospective Study

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## Research article

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# Abstract

**Background:** Arthroscopic resection of the distal clavicle has the potential risk of inadequate resection that may be associated with residual postoperative pain. We propose a new arthroscopic technique to excise the distal clavicle precisely and reproducibly without causing impingement or instability of the acromioclavicular (AC) joint. The purpose of this study was to evaluate the clinical and radiological results of arthroscopic distal clavicle resection in patients with symptomatic AC joint osteoarthritis.

**Methods:** We retrospectively evaluated 26 patients (mean age,  $55.3 \pm 16.0$  years) who underwent arthroscopic distal clavicle resection between April 2010 and September 2017 with a minimum 1-year follow-up (mean follow-up,  $25.3 \pm 11.1$  months). Nine of these patients also underwent rotator cuff repair. Clinical evaluations performed preoperatively and at final follow-up included subjective pain scores according to a visual analogue scale (VAS), range-of-motion examinations, UCLA scores, and Shoulder-36 scores. Shoulder muscle strengths were measured with a handheld dynamometer. The amount of distal clavicle resection was measured on plain radiographs.

**Results:** No patients had AC joint tenderness. There were significant differences between the preoperative and postoperative VAS, UCLA, and Shoulder-36 scores ( $P < 0.05$ ). Muscle strengths were measured preoperatively and at final follow-up in 14 patients. Elevation and internal rotation strengths were significantly greater postoperatively, but there was no significant difference in external rotation strength. The mean amount of distal clavicle resection was  $14.1 \pm 2.1$  mm. The mean coracoclavicular distance was  $8.4 \pm 1.6$  mm preoperatively and  $8.6 \pm 1.8$  mm at final follow-up, with no significant difference.

**Conclusions:** Our arthroscopic technique of distal clavicle resection for AC joint osteoarthritis resulted in successful clinical outcomes at final follow-up. Bone resection was performed according to the amount planned, as confirmed on postoperative radiographs. The technique allows resection of the distal clavicle with accurate shape and amount as planned preoperatively with no postoperative instability of the AC joint.

## Background

Acromioclavicular (AC) joint osteoarthritis is a frequent cause of anterosuperior shoulder pain and can be caused by age-related degeneration and mechanical stress resulting from overhead and cross-body athletic or occupational activities [1–3]. The reported prevalence of AC joint pain is 0.5/1000 people/year in the primary care setting [4]. A previous study found that 54–57% of elderly patients exhibited radiographic degeneration of the AC joint [5]. AC joint arthritis is diagnosed on the basis of AC joint swelling on visual inspection and tenderness on palpation. The most reliable provocative test on physical examination is the cross-body adduction test [6]. Radiographs can demonstrate degenerative changes, including joint-space narrowing, osteophytes, sclerosis, and subchondral bone cysts in the AC joint on Zanca views [7]. Meanwhile, magnetic resonance imaging (MRI) can reveal edema and bone marrow signal changes in the articular surface of the clavicle and acromion, which may indicate osteoarthritic

changes in the AC joint. Typical initial treatments for AC joint pain include rest, immobilization, nonsteroidal anti-inflammatory medication, intra-articular injection therapy, and physical therapy [2, 8]. When non-surgical treatment fails to provide adequate pain relief, distal clavicle resection, a reliable procedure previously reported by Mumford [9], is recommended.

Several authors have reported that the extent of resection affects postoperative outcomes. Excessive resection of the distal clavicle can lead to postoperative AC joint instability, whereas insufficient resection can lead to persistent shoulder pain resulting from residual AC contact [6, 10]. Stein et al. [11] reported that the mean distances from the end of the lateral clavicle to the beginning of the trapezoid and conoid ligaments were 14.7 mm and 32.1 mm, respectively. Because of this attachment morphology, we believe that an excision of less than 15 mm will not affect AC joint stability. The critical amount of resection remains controversial, with most authors recommending 5–15 mm of resection; however, there is a large variation in reported resection volumes [1, 6, 10, 12–16]. Arthroscopic resection of the distal clavicle has recently been developed as a less invasive alternative to open surgery that enables preservation of the clavicular attachments of the deltoid and trapezius muscles and faster return to normal activities. Arthroscopy also allows the diagnosis of other pathologies within the glenohumeral joint and subacromial space [17–19]. However, reported disadvantages of this approach include a higher risk of inadequate resection compared with the open procedure because of technical challenges [1, 14, 20]. It was reported that postoperative pain can remain after distal clavicle resection due to residual small bone fragments, ectopic ossification, and the residual superior cortex at the distal clavicle after insufficient resection [15, 17, 21–23]. Furthermore, Elhassan et al. [17] and Levine et al. [24] described that revision resections were required because of inadequate distal clavicular resection. With techniques involving observation and excision of the distal clavicle with a burr from below, much of the lower surface of the distal clavicle tends to be excised. Thus, it is difficult to cut the distal clavicle vertically and a superior clavicle stump tends to remain. Insufficient resection can lead to inferior postoperative outcomes [25]. To avoid this unfavorable situation, it is necessary to confirm the clavicle stump frequently with fluoroscopic examination. This frequent verification increases radiation exposure for the operator and medical staff and lengthens the time of the surgery.

We propose a new arthroscopic technique to excise the distal clavicle precisely and reproducibly as planned without causing impingement or instability of the AC joint and to reduce operators' radiation exposure during surgery. The purpose of this study was to evaluate the clinical and radiological results of arthroscopic distal clavicle resection in patients with symptomatic AC joint osteoarthritis.

## Materials And Methods

We retrospectively evaluated the clinical and radiological results of arthroscopic distal clavicle resection in patients with symptomatic AC joint osteoarthritis. This single-center retrospective cohort study included patients treated between April 2010 and September 2017 and was approved by the Institutional Review Board of Fukuoka University Chikushi Hospital (approval number, R17-037).

Inclusion criteria for the study were: (1) localized pain and tenderness at the AC joint with failure of non-surgical treatment for at least 6 months, and osteoarthritis confirmed by imaging; (2) complete temporary relief of pain after injection of 2–3 mL of lidocaine into the AC joint; (3) resection of the distal clavicle using our arthroscopic procedure; (4) no previous surgery on the affected shoulder; and (5) at least 1 year of follow-up with appropriate radiographs after surgery. Patients with a history of trauma (e.g., AC joint dislocation or concomitant injury with proximal humeral fracture, shoulder dislocation, or distal clavicle fracture) were excluded to avoid bias related to comorbidities that could affect the results.

A total of 31 patients (24 men, seven women) with AC joint arthritis were included in the study. MRI revealed that nine of these patients had rotator cuff tears. The mean patient age was  $54.2 \pm 17.5$  years. Five patients were lost to follow-up and were excluded from the study. The remaining 26 patients (19 men, seven women) were included in the analysis. The mean patient age at the time of surgery was  $55.3 \pm 16.0$  years (range, 21–75 years). The minimum follow-up period was 1 year (mean,  $25.3 \pm 11.1$  months; range, 12–59 months).

All patients underwent standard radiographic evaluations, including anteroposterior, axillary, and Zanca views of the AC joint. Preoperative and postoperative radiographs were available for all patients. MRI was performed in all patients prior to surgery.

## Surgical procedure

The senior author (Y.S.) performed all of the operations. The patient was seated in the beach-chair position while under general anesthesia with an interscalene block. During arthroscopy, an arm holder (Arm Controller; OHTA Inc., Okayama, Japan) was used to hold the arm in the desired position. Intra-articular lesions in the glenohumeral joint were observed with a 30° arthroscope via a standard posterior portal. An anterior portal through the rotator interval was used as the working portal. In patients with paraglenoid labral cyst or superior labrum anterior and posterior lesions, debridement of the superior labrum or curettage of the cyst was performed through the anterior or lateral portal. A lateral portal to the subacromial space was then created for viewing. The subacromial bursa was removed until adequate visualization of the undersurface of the acromion was achieved through the anterolateral portal (ALP). Arthroscopic subacromial decompression was performed in patients with impingement signs. Rotator cuff repair was performed in patients with rotator cuff tears.

Under fluoroscopic imaging, two 18-gauge needles were inserted percutaneously and vertically into the AC joint space, one at the anterior edge and one at the posterior edge. Two 1.8-mm diameter Kirschner wires (K-wires) penetrated the clavicle perpendicular to its axis and parallel to the inserted needles. The distance between the needles and the K-wires was 15 mm at the skin level. One K-wire was inserted at the anterior edge of the clavicle and the other at the posterior edge. The plane composed of the two needle insertion points on the upper surface of the AC joint and the two protrusions on the undersurface of the joint was parallel to the plane composed of the two K-wire insertion points on the upper surface of the clavicle and the two protrusions on the undersurface of the clavicle (Fig. 1). The 18-gauge needles

protruding from the skin indicated the position of the AC joint; the subacromial bursa below the AC joint was ablated until the needle tips were visualized completely (Fig. 2). After confirming the exact position of the AC joint, the lower surface of the distal clavicle was excised freehand with a 5.5-mm burr inserted through the ALP. A switching rod was inserted via the anterior portal through the space made by resection of the lower surface of the distal clavicle and penetrated the skin behind the AC joint. These additional two portals, which were described by Flatow et al. [26], were created anterior and posterior to the AC joint. Excision of the distal clavicle was performed with the burr until the plane made by the two parallel K-wires was completely visualized. Finally, complete and appropriate excision of the distal clavicle was confirmed by fluoroscopic imaging (Fig. 3).

## Postoperative rehabilitation

The shoulder was immobilized with a sling and bandage after surgery. Pendulum and passive range-of-motion (ROM) exercises were started at 4 days after surgery. After 3 weeks, the sling was removed and active ROM exercises were gradually introduced. In patients who underwent rotator cuff repair, sling removal and active ROM exercises were started at 6 weeks after surgery. Muscle strengthening exercises were started at 6 weeks after distal clavicle resection alone and 9 weeks after rotator cuff repair.

## Clinical evaluations

Preoperative and postoperative subjective pain scores at rest, at night, and on motion were measured with a visual analogue scale (VAS), in which 0 mm represented 'not painful' and 100 mm represented 'pain intensity that could not be tolerated'. The University of California Los Angeles (UCLA) score and Shoulder-36 score were used for clinical assessment. Shoulder-36 is a patient-based subjective scoring system introduced by the Japan Shoulder Society [27]. Abduction, external rotation at the side, internal rotation (assessed by the spinous process level that the thumb can reach behind the back), and horizontal flexion were used to assess the ROM before and after surgery. Strengths of the shoulder muscles were measured with a portable handheld dynamometer (MicroFET 2®; Hoggan Scientific LLC, Salt Lake City, UT, USA). Elevation strength was tested with the patient in the seated position with 90 degrees of shoulder abduction in the scapular plane. External and internal rotator strengths were tested with the arm at the side with the shoulder in neutral rotation and the elbow at 90 degrees of flexion.

## Radiological evaluation

Radiological evaluation was performed in all patients. To evaluate the amount of bone resection at the distal clavicle, the AC joint interval was compared before surgery and at final follow-up on plain Zanca view radiographs [7]. Postoperative clavicle translation was evaluated by measuring the coracoclavicular distance preoperatively and at final follow-up (Fig. 4).

# Statistical analysis

The paired *t*-test and Mann–Whitney U test were used for statistical analyses. Data were analyzed with GraphPad Prism version 5.0 (GraphPad Software, San Diego, CA, USA). The level of significance was set at  $P < 0.05$ .

## Results

### Clinical outcomes

Among the total of 26 patients, arthroscopic rotator cuff repair was performed in nine patients, a paraglenoid labral cyst was debrided in one patient, and anterior and posterior lesions of the superior labrum were debrided in one patient. The cross-body adduction test and AC joint tenderness had resolved in all patients by the final follow-up. The mean preoperative VAS scores for subjective pain at rest, at night, and on motion were  $27.6 \pm 26.6$  mm (range, 3–93 mm),  $43.9 \pm 28.0$  mm (range, 3–86 mm), and  $69.2 \pm 24.9$  mm (range, 13–100 mm), respectively. The mean VAS scores at final follow-up at rest, at night, and on motion were  $5.2 \pm 7.7$  mm (range, 0–25 mm),  $7.8 \pm 10.0$  mm (range, 0–35 mm), and  $13.8 \pm 13.0$  mm (range, 0–45 mm), respectively ( $P < 0.001$ ,  $P < 0.0001$ , and  $P < 0.0001$ , respectively). The mean UCLA and Shoulder-36 scores were significantly higher at final follow-up than before surgery ( $P < 0.0001$  and  $P < 0.01$ , respectively). ROMs in flexion, internal rotation, and horizontal flexion at final follow-up were significantly greater than those before surgery. There was no significant difference for ROM in external rotation before surgery versus final follow-up (Table 1).

Muscle strength was measured before surgery and at final follow-up in 14 patients. Muscle strengths in elevation, external rotation, and internal rotation on the affected side were significantly weaker than those on the unaffected side preoperatively. There was no significant difference in muscle strengths between the affected and unaffected sides at final follow-up. Elevation and internal rotation strengths were significantly greater after surgery than before surgery, but there was no significant difference in external rotation strength (Table 2).

### Radiological evaluation

The mean amount of bone resection at the distal clavicle was  $14.1 \pm 2.1$  mm (range, 10.0–17.7 mm). The coracoclavicular distance was  $8.4 \pm 1.6$  mm (range, 5.3–11.0 mm) before surgery and  $8.6 \pm 1.8$  mm (range, 3.3–11.3 mm) at the final follow-up, with no significant difference. There were no cases of postoperative clavicle translation.

## Discussion

The most important finding of the present study was that it is possible to excise the distal end of the clavicle with accurate amount and shape using our technique involving two K-wires. In previous reports,

needle insertion techniques to identify the exact location of the AC joint [12, 17, 23, 26] and viewing portals to evaluate the amount of distal clavicle resection [28, 29] were described. However, there are few reports on specialized arthroscopic techniques for distal clavicle resection. We penetrated two K-wires perpendicular to the clavicular axis and parallel to the inserted needles until they penetrated the lower surface of the distal clavicle at the planned excision site and excised the distal clavicle to the penetration points of the K-wires arthroscopically. It was possible to excise the distal clavicle vertically, meaning that there was no risk of insufficient resection or residual superior cortex at the distal clavicle, which can lead to a risk of reoperation. The originality of our procedure is the insertion of two K-wires at the resection margin to allow the distal clavicle resection as planned preoperatively.

Open and arthroscopic distal clavicle resection techniques have been performed for symptomatic AC joint osteoarthritis that does not respond to several months of non-surgical treatment [2–4]. Insufficient resection can result in persistent pain caused by residual impingement between the distal clavicle and the acromion. Excessive resection can lead to instability of the scapular girdle resulting from injury to the coracoclavicular ligament [25]. In a cadaveric study, Stein et al. [11] reported that the mean distance from the end of the lateral clavicle to the beginning of the trapezoid ligament was 14.7 mm. Harris et al. [30] reported that the mean distance between the end of the clavicle and the most lateral fibers of the trapezoid ligament was 15.3 mm. Therefore, we judged that the amount of distal clavicle resection should be up to approximately 15 mm to avoid damage to the trapezoid ligament. Several authors have suggested that the critical resection length of the distal clavicle ranges from 5 to 15 mm, but there is still no consensus on the amount required to maintain AC joint stability and prevent contact between the distal clavicle and the acromion [15]. Gartsman et al. [1] reported that 1.5 cm was an appropriate resection amount. Kay et al. [12] resected 1 cm in 10 patients with satisfactory results. Meanwhile, Eskola et al. [31] found that patients with resections of less than 10 mm had significantly better outcomes and less pain than patients with resections exceeding 10 mm. However, Rabalais et al. [10] commented that the study by Eskola et al. included a variety of patients with AC joint separations and fractures, making it difficult to generalize their conclusions on the association between pain and the amount of AC joint resection. Previous cadaver studies showed that a 5-mm resection was adequate to prevent bony abutment in both rotationally and axially loaded shoulders [32, 33]. However, two cases (8.2%) with insufficient excision of the superior part or posteroinferior part of the distal clavicle were reported in a study with a mean distal clavicle resection length of 5.4 mm [29]. In addition, Elhassan et al. [17] reported that a reoperation was required in 5 of 81 cases (6.2%) because of persistent or recurrent pain resulting from inadequate distal clavicle resection or bony regrowth of the distal clavicle, despite a mean AC joint space of 9.5 mm after resection. In a long-term study with a mean follow-up of 6 years, Kay et al. [34] reported that the traditional clavicle resection of 1.0–1.5 cm may be more appropriate to prevent long-term impingement, because 25% of the postoperative radiographs showed evidence of calcified density at the distal clavicle. In our study, a 15-mm excision of the distal clavicle was performed as the maximum excision possible without damaging the trapezoid ligament and without impingement between the distal clavicle and the acromion. In postoperative measurements, the mean amount of bone resection at the distal clavicle was  $14.1 \pm 2.4$  mm, which matched the amount determined in the preoperative planning.

AC joint arthritis mainly results from overuse and aging in manual workers. Under similar conditions, rotator cuff tears can develop as concomitant lesions. In recent years, distal clavicle resection for AC joint arthritis has been performed arthroscopically, and it is possible to simultaneously treat rotator cuff lesions. Kim et al. [35] reported good results for arthroscopic distal clavicle resection combined with rotator cuff repair. Arthroscopic distal clavicle resection is a useful method that can simultaneously treat concomitant rotator cuff lesions.

Excellent outcomes have been reported after arthroscopic distal clavicle resection [1, 14, 18–20, 26, 31]. However, Strauss et al. [25] reported postoperative instability of the AC joint that required additional ligament reconstruction. In our method, the orientation of the distal clavicle is determined using the landmarks of the two needles during the bursal side arthroscopy. The distal clavicle undersurface is removed to expose the tips of the two K-wires, which are located at the most medial position of the resection area where the lateral edge of the trapezoid ligament is attached. The distal undersurface of the clavicle is resected via the ALP. The distal upper surface of the clavicle can be resected accurately via Flatow's portal based on the plane created by the two K-wires. The K-wires are recognized as landmarks for the amount of the distal clavicle resection. This not only allows for a correct plane and amount of the distal clavicle resection, but also avoids excessive ablation of the inferior surface of the clavicle where there is a risk of damaging the trapezoid ligament. In addition, an advantage of our technique is that fluoroscopy is only used for the initial insertion of the needles and K-wires during surgery, and this can reduce the operators' radiation exposure and use of frequent fluoroscopic imaging to confirm the resection volume. In our study, there was no significant difference in preoperative versus postoperative coracoclavicular distances and no cases had postoperative AC joint instability.

Arthroscopic distal clavicle resection may have several advantages over the open procedure. The former reduces injury and weakness of the deltoid and trapezius muscles and minimizes postoperative pain. These advantages result in a shorter rehabilitation period, which enables a quicker return to work [23, 36]. In our study, there were no significant differences in the strengths of elevation, external rotation, or internal rotation between the affected and unaffected sides after surgery. Postoperatively, muscle strengths for elevation and internal rotation showed greater improvements than those for external rotation. These findings may have resulted from decreased AC joint pain. Usually, patients with AC joint osteoarthritis experience pain when they elevate or internally rotate their shoulder. These motions increase the compression force on the AC joint. In contrast, during external rotation, traction force is applied to the AC joint, which causes less pain, both before and after surgery. This may explain why there was no significant difference in external rotation strength before versus after surgery.

Arthroscopic distal clavicle resection is minimally invasive, but technically demanding. Therefore, it is necessary to establish a simple and reproducible surgical method, and such a procedure can promise good clinical outcomes and reduced complications. Although our technique may not be necessary for skilled arthroscopists, we believe that it is a useful aid for resident-level arthroscopists who have difficulty in accurately determining the orientation of the distal clavicle and resecting a precise volume and shape. We believe that this method can promote accurate surgery and may save time.

Our study has several limitations. First, this was a retrospective study with a relatively small sample size and short follow-up period. Second, the muscle strengths were not measured preoperatively and postoperatively in all patients. Third, we did not consider the trapezoid ligament attachment area because of sex-related differences and physique differences among patients [37]. Thus, the resection amount was based on the mean attachment range of the trapezoid ligament in a previous anatomical study [11]. In our study, the amount of resection was larger than that reported in previous studies [15–17, 19, 26, 29, 32, 33]. However, we were extremely worried that the additional resection could have been required because of AC joint impingement that resulted in remaining oblique or occurring regrowth. We believe that this amount of resection is acceptable, because excellent clinical outcomes were obtained, no revision surgery was needed, and no postoperative radiographs showed AC joint instability.

## Conclusions

Our technique for arthroscopic resection of the distal clavicle for AC joint osteoarthritis resulted in excellent clinical outcomes. Accurate shape and amount of bone resection were achieved according to the preoperative plan and no postoperative instability of AC joint occurred. This technique minimizes radiation exposure and enables reproducible and accurate distal clavicle resection.

## Abbreviations

AC: acromioclavicular; MRI: magnetic resonance imaging; K-wires: Kirschner wires; ROM: range of motion; VAS: visual analogue scale; UCLA: University of California Los Angeles.

## Declarations

### Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Fukuoka University Chikushi Hospital (IRB approval number: R17-037).

### Consent for publication

Not applicable.

### Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

### Competing interests

All authors declare that they have no competing interests.

## Funding

We have no funding.

## contributions

All authors helped with data collection and contributed to the writing and critical revisions for intellectual content and final approval of the article.

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## Tables

Table 1. Pre- and postoperative VAS scores, clinical outcome scores (UCLA and Shoulder-36 scores), and ROM measurements

		Preoperative	Postoperative	P-value
Pain VAS score	rest (mm)	27.6 ± 26.6 (range 3-93)	5.2 ± 7.7 (range 0-25)	<0.001
	night (mm)	43.9 ± 28.0 (range 3-86)	7.8 ± 10.0 (range 0-35)	<0.0001
	motion (mm)	69.2 ± 24.9 (range 13-100)	13.8 ± 13.0 (range 0-45)	<0.0001
UCLA score (points)		14.9 ± 4.1 (range 7-22)	31.9 ± 3.4 (range 25-35)	<0.0001
Shoulder 36 (points)		93.8 ± 26.9 (range 40-138)	121.5 ± 30.0 (range 38-144)	<0.01
ROM	Flex (degrees)	119.8 ± 32.5 (range 50-170)	149.8 ± 18.5 (range 110-180)	<0.001
	ER (degrees)	49.4 ± 20.2 (range 10-80)	56.4 ± 22.4 (range 10-100)	0.17
	IR (vertebra)	L2.1 ± 3.8 (range hip-Th6)	Th10.9 ± 3.7 (range L5-Th6)	<0.01
	Horizontal flex (degrees)	97.3 ± 26.9 (range 30-140)	115.6 ± 16.5 (range 75-145)	<0.001

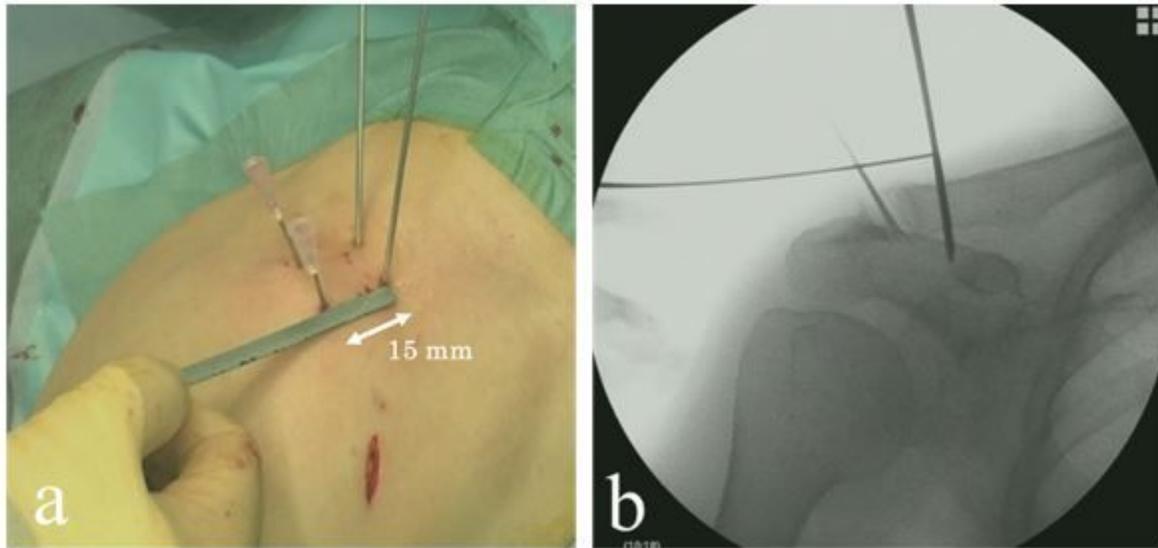
VAS: Visual analogue scale, UCLA: University of California Los Angeles shoulder rating scale, ROM: Range of motion, Flex: Flexion, ER: External rotation, IR: Internal rotation

Table 2. Pre- and postoperative muscle strength (kg weight)

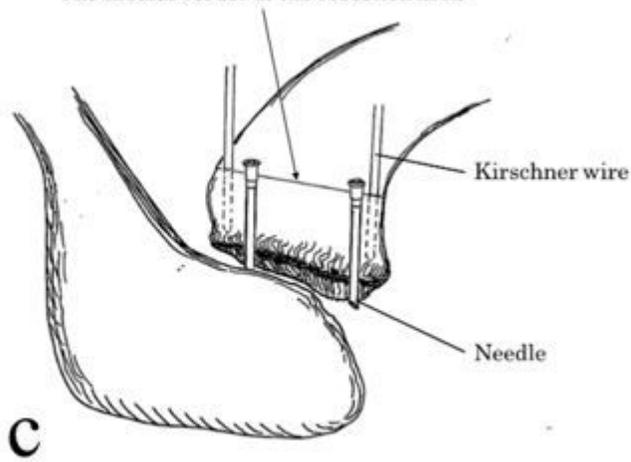
		Preoperative	Postoperative	P-value
Abduction	Affected side	9.5 ± 8.7 (range 0.0-30.9)	15.7 ± 6.3 (range 4.3-25.1)	<0.05
	Unaffected side	17.4 ± 6.3 (range 4.6-26.2)	18.4 ± 6.1 (range 8.9-25.4)	0.59
	P-value	<0.001	0.09	
ER	Affected side	11.0 ± 5.3 (range 4.2-19.4)	12.7 ± 5.0 (range 3.5-20.5)	0.31
	Unaffected side	16.0 ± 7.2 (range 5.5-28.4)	14.0 ± 4.5 (range 8.0-21.8)	0.15
	P-value	<0.01	0.10	
IR	Affected side	12.7 ± 6.7 (range 3.8-25.9)	16.8 ± 6.1 (range 6.9-25.9)	<0.05
	Unaffected side	18.9 ± 9.3 (range 6.0-39.8)	15.8 ± 6.3 (range 7.0-27.0)	0.17
	P-value	<0.001	0.73	

ER: External rotation, IR: Internal rotation

## Figures

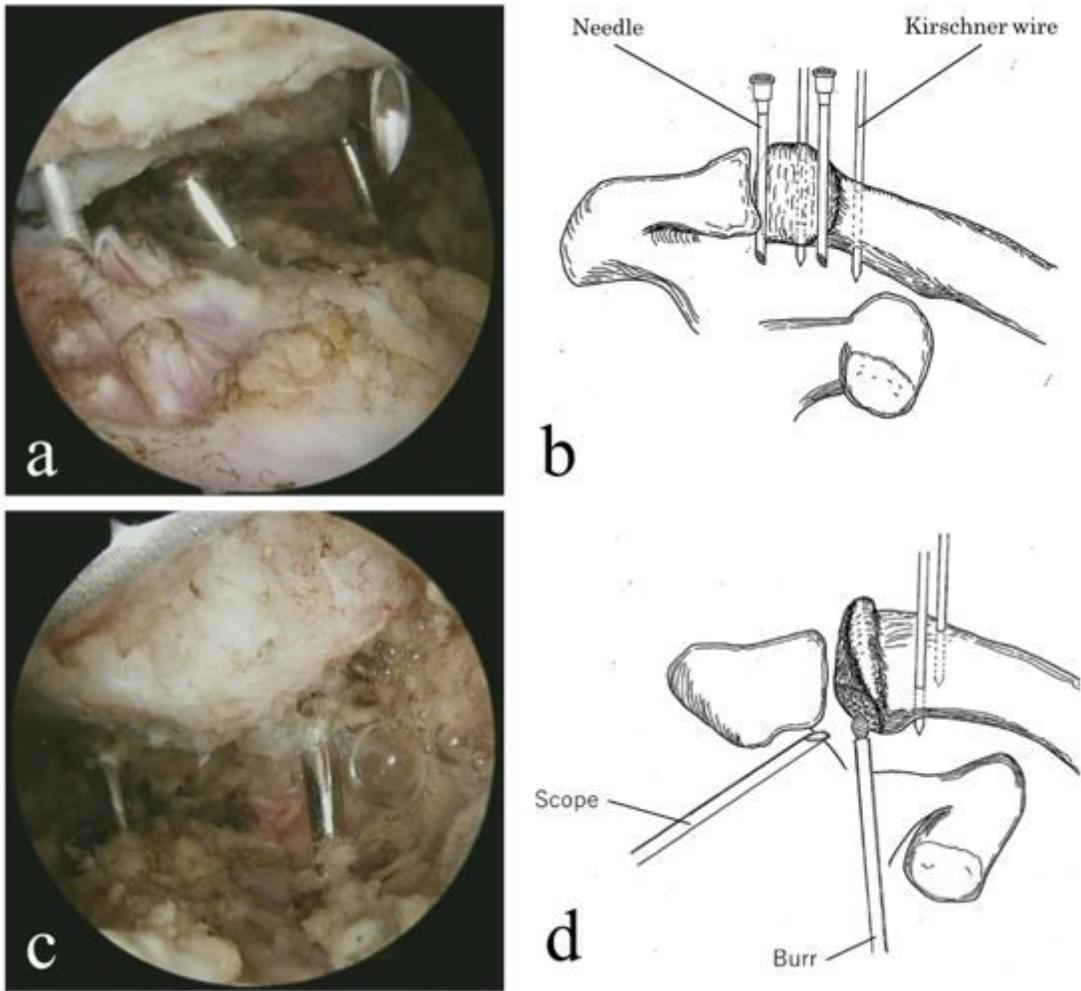


The medial border of the resection area



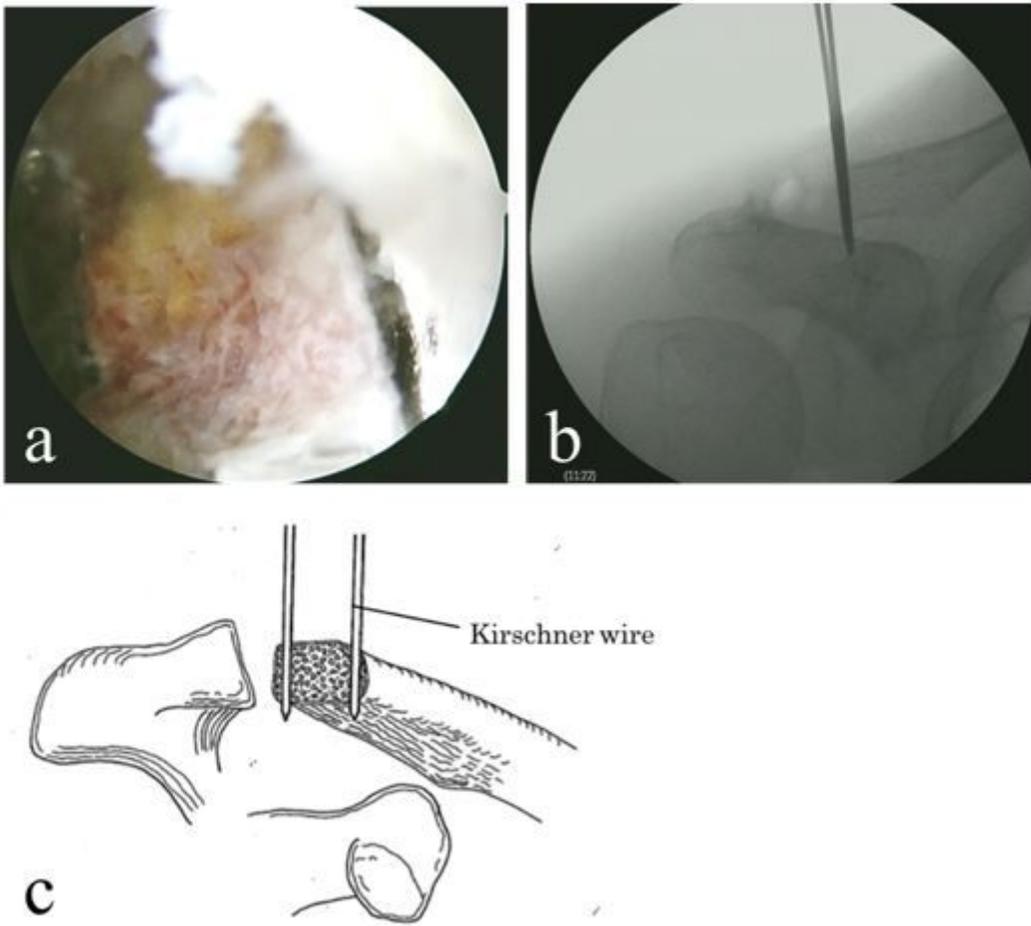
## Figure 1

Identification of the AC joint and confirmation of the amount of distal clavicle resection at the skin level (a) and by fluoroscopic imaging (b). Two 18-gauge needles are inserted percutaneously into the acromioclavicular joint and two 1.8-mm diameter Kirschner wires are inserted in the clavicle at the medial border of the resection area (c)



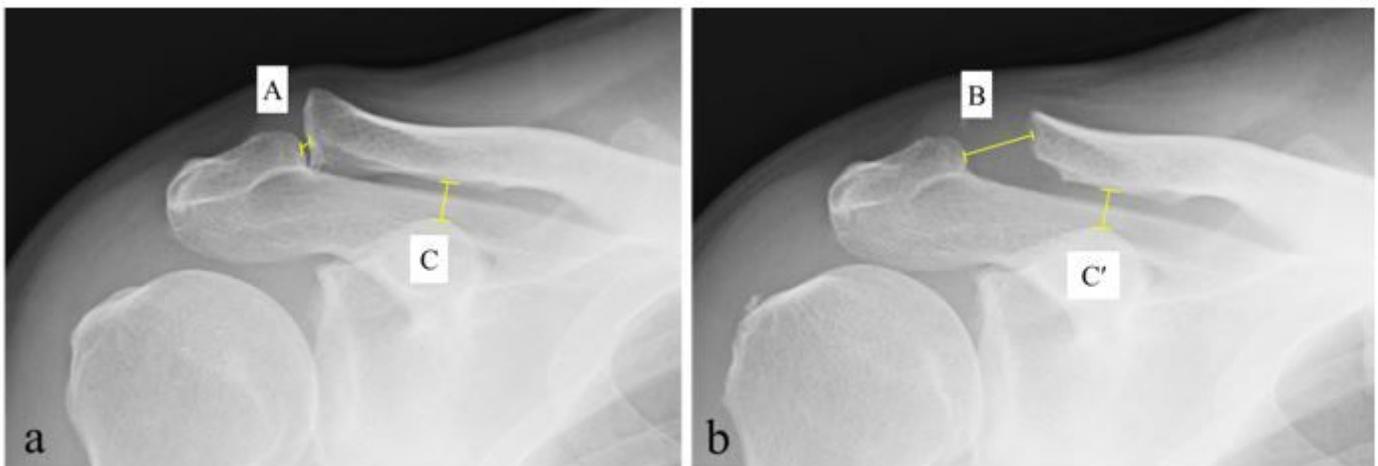
**Figure 2**

Arthroscopic view from bursal side arthroscopy (right shoulder). The correct position of the AC joint and lower surface of the distal clavicle are visualized completely. (a, b) The lower surface of the distal clavicle is excised with a burr inserted via the anterior surface of the acromioclavicular joint (c, d)



**Figure 3**

Confirmation of the complete and appropriate excision of the distal clavicle on the view from the posterior portal (a) and by fluoroscopic imaging (b). The two parallel K-wires were completely visualized at the distal clavicle end (c)



## Figure 4

Plain Zanca view radiographs before surgery (a) and at final follow-up (b). The amount of bone resection was calculated according to the difference in the acromioclavicular distance before surgery (A) versus final follow-up (B). Clavicle translation was evaluated by measuring the coracoclavicular distance (C).