

# CiSE

## Clinics in Shoulder and Elbow

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Volume

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Editorial

Is common the rotator cuff tear in the calcific tendinitis?

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Concise Review

Complications of reverse shoulder arthroplasty: a concise review

# CiSE

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### Aims and Scope

*Clinics in Shoulder and Elbow* (Clin Shoulder Elbow, CiSE; eISSN: 2288-8721) (pISSN: 2383-8337 till 2018) is an international, peer-reviewed journal and the official journal of Korean Shoulder and Elbow Society. It was first launched in 1998 (from March 1998 to June 2010: Journal of the Korean Shoulder and Elbow Society). It is published quarterly in the first day of March, June, September, and December, with articles in English, and has been published as an online-only journal since 2019.

The purposes of CiSE are: first, to contribute in the management and education of shoulder and elbow topics; second, to share latest scientific informations among international societies; and finally, to promote communications on shoulder/elbow problems and patient care. It can cover all fields of clinical and basic researches in shoulder and elbow.

CiSE publishes papers on basic and clinical researches, focusing on areas such as the etiology and epidemiology, biomechanics and pathogenesis, management and surgery, complication and prognosis for disease of shoulder and elbow. The manuscripts in the following categories can be submitted: original articles, case reports, invited review articles, editorials and letters to the editor. All submissions are processed online ([www.cisejournal.org](http://www.cisejournal.org)). The publication is determined by the editors and peer reviewers, who are experts in their specific fields of shoulder and elbow.

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**Editorial office**  
Korean Shoulder and Elbow Society  
Department of Orthopaedic Surgery, Seoul National University Hospital, #6603, 101 Daehak-ro, Jongno-gu, Seoul 03080, Korea  
Tel: +82-2-3410-1854 Fax: +82-2-3410-0061 E-mail: [journal@cisejournal.org](mailto:journal@cisejournal.org)

**Printing office**  
M2PI  
8th FL, DreamTower, 66 Seongsui-ro, Seongdong-gu, Seoul 04784, Korea  
Tel: +82-2-6966-4930 Fax: +82-2-6966-4945 E-mail: [support@m2-pi.com](mailto:support@m2-pi.com)

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# Is common the rotator cuff tear in the calcific tendinitis?

Jong-Hun Ji, Jae-Hoon Kim

*Department of Orthopedic Surgery, Daejeon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Daejeon, Korea*

Little information is available about calcific tendinitis of the shoulder combined with rotator cuff tears. The diagnosis and treatment of general calcific tendinitis of the shoulder is well established [1]. However, calcific tendinitis and coexisting rotator cuff tear have completely different disease characteristics and these concerns have prompted research on the true incidence of combined rotator cuff tears in calcific tendinitis and their management. The relationship between calcifying tendinitis and rotator cuff tear remains controversial. Previously, it was strongly believed that these entities could not coexist [2]. Calcific tendinitis and rotator cuff tear are common causes of the chronic shoulder pain. However, the pathogenesis, age predominance, and treatment of calcific tendinitis and rotator cuff tears are completely different. Calcific tendinitis usually peaks in the fifth decade of life, whereas rotator cuff tendon tear continues to increase with age [3]. Also, the true incidence of rotator cuff tears in calcific tendinitis of a Korean population is not well known. There have been few studies about calcific tendinitis combined with rotator cuff tear, especially in a Korean population.

In a study by Yoo et al. [4] entitled "Calcific tendinitis of the shoulder in the Korean population: demographics and its relation with coexisting rotator cuff tear" the authors investigated the demographic, clinical, and radiological factors of calcific tendinitis of the shoulder joint in a large number of Koreans and calculated the prevalence of rotator cuff tear associated with calcific tendi-

nitis. This was a multicenter study involving a large population. This retrospective study enrolled 506 patients diagnosed with calcific tendinitis of the shoulder at 11 major training hospitals nationwide.

Calcific deposits are often located 1 to 2 cm from the insertion of the supraspinatus tendon on the greater tuberosity and often cause severe shoulder pain and limited daily activities [3,5]. Typical calcific tendinitis shows variable functional impairment and symptoms, ranging from months to years; these symptoms were typically self-limiting [5,6]. Most patients (nearly 90%) can be treated nonoperatively, which includes activity modification, rest, physiotherapy, cold pack or hot pack massage, ultrasound, extracorporeal shock wave therapy, needle lavage, subacromial steroid injection and nonsteroidal anti-inflammatory medications. Although the majority of these patients respond to the above conservative treatments, some patients show persistent shoulder pain and often require operative management.

Surgical treatment should be considered when conservative measures have failed, or when coexisting rotator cuff tear requiring repair is confirmed by radiologic evaluation such as magnetic resonance imaging (MRI) and ultrasonography (US). Recently, arthroscopic debridement of calcific deposits and rotator cuff repair have been found to yield excellent functional results and high patient satisfaction. However, de Witte et al. [7,8] reported that pain and discomfort of the shoulder still persisted in more

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Correspondence to: Jong-Hun Ji

Department of Orthopedic Surgery, Daejeon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 64 Daeheung-ro, Jung-gu, Daejeon 34943, Korea

Tel: +82-42-220-9530, Fax: +82-42-221-0429, E-mail: [jjjh87@gmail.com](mailto:jjjh87@gmail.com), ORCID: <https://orcid.org/0000-0003-1087-3254>

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than 50% of patients even after 14 years of follow-up, and that female sex, dominant arm involvement, bilateral disease, longer duration of symptoms, and multiple calcifications were associated with inferior outcomes.

In this study, the average age of symptom onset in calcific tendinitis was 55 years, with onset occurring in patients in their 50s (45%), 60s (23%), and 40s (21%), respectively. It tended to be more prevalent in females. About 71% of patients had a high rate of nightly pain. For treatment, oral analgesics (93%) were the most common, followed by steroid injection therapy (53%). In total, 79% of cases were in the dominant arm, 19% in the non-dominant arm, and 12.6% of patients had a history of trauma before symptoms. The occupation of those who developed calcific tendinitis was unemployed/housekeeping (37%), laborers (21%), office workers (19%), and others (17%). In total, 21% engaged in regular exercise and 15% exercised their shoulders. The current smokers were 42 (8%), diabetes (12%), thyroid disease (6%), and rheumatic disease (3%) were found. Among 377 female patients, 47% had experienced menopause, and 10% had a history of obstetric disease.

One arthrography study showed that a rotator cuff tear coexists in approximately 25% of patients presenting with calcific tendinitis [9]. Another study by Hsu et al. [10] showed that calcific tendinitis and rotator cuff tear were concomitant in 28% of patients on shoulder angiography and that calcium deposits were rather small in patients with rotator cuff tear. Compared to previous studies, this study using sonography or MRI showed a low incidence of combined rotator cuff tears in calcific tendinitis. Among 383 patients (76%), 59 (15%) had rotator cuff tears, including 15 (3.9%) full-thickness tears, 22 (5.7%) bursal side partial tears and 22 (5.7%) articular side partial tears on US or MRI. Without arthroscopic or open diagnosis of rotator cuff tears, the diagnostic accuracy of US or MRI alone may have affected the reliability of the study.

As a diagnostic tool, MRI is often used to diagnose combined rotator cuff tears in calcific tendinitis. The calcific materials (artifacts) could prevent clear imaging of rotator cuff tears. If the calcific deposits did not occur in the same location as the rotator cuff tear, the tears were easy to diagnose. However, if the location of the calcific deposit coincided with the site of rotator cuff tear, it can be difficult to differentiate rotator cuff tears from calcific tendinitis. Even though MRI technology has improved, rotator cuff tear combined with calcific tendinitis in an adjacent location are difficult to diagnose owing to calcific material artifacts. In particular, low signal fragments of calcification or signs of tendinitis can overlook partial thick rotator cuff tears in MRI, often resulting in higher than expected signals in fluid-sensitive se-

quences.

Even though the main cause of shoulder pain was calcific deposits, rotator cuff tear could be a cause of symptomatic shoulder pain. In this study, the authors [4] suggested that a poor prognosis was shown by patients with persistent symptoms, old age, patients with recurring symptoms, and patients with menstrual irregularities further radiographic study to evaluate rotator cuff tear might be needed in some calcific tendinitis patients with older age and recurrent symptoms.

Shoulder surgeons should be cautioned about rotator cuff tears as a comorbidity in calcific tendinitis and also should be aware of the accuracy limitations of sonographic or MRI evaluation of combined rotator cuff tears. Furthermore, in long-standing calcific tendinitis combined with rotator cuff tears, simultaneous rotator cuff repair with calcific deposit removal should be considered to improve clinical outcomes.

## ORCID

Jong-Hun Ji <https://orcid.org/0000-0003-1087-3254>  
Jae-Hoon Kim <https://orcid.org/0000-0003-1565-9978>

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## Original Article

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# The effects of a single-dose subacromial injection of a nonsteroidal anti-inflammatory drug in geriatric patients with subacromial impingement syndrome: a randomized double-blind study

Young Bae Kim, Woo-Seung Lee, Jun-Sung Won

Department of Orthopedic Surgery, Veterans Health Service Medical Center, Seoul, Korea

**Background:** As nonsteroidal anti-inflammatory drugs (NSAIDs) and steroids have similar effects, steroids can be avoided to reduce adverse effects. This study aimed to compare the differences in symptom improvement after subacromial injection of steroids or NSAIDs.

**Methods:** Sixty patients with rotator cuff syndrome for at least 3 months were enrolled and divided into steroid and NSAID groups. The steroid group received a mixture of 1 mL of triamcinolone acetonide (40 mg/mL) and 1 mL of lidocaine hydrochloride 2%, while the NSAID group received a mixture of 1 mL of Ketorolac Tromethamine (30 mg/mL) and 1 mL of lidocaine hydrochloride 2%. The patients were assessed before and at 3, 6, and 12 weeks after the procedure. Shoulder scores from visual analog scale (VAS), American Shoulder and Elbow Surgeons (ASES), and University of California Los Angeles (UCLA) were used for evaluation.

**Results:** Both groups showed improvements in the clinical outcomes. Overall VAS, ASES, and UCLA scores improved from 6.9, 32.7, and 16.0 before the procedure to 2.0, 1.2, and 1.1; 81.5, 87.6, and 88.5; and 29.7, 31.8, and 32.0 at weeks 3, 6, and 12 weeks after the procedure, respectively. Twenty-six patients (86.7%) in the steroid group and 28 (93.3%) in the NSAID group reported satisfactory treatment outcomes. There were no significant differences in the outcomes between the two groups ( $p=0.671$ ).

**Conclusions:** Subacromial injection of NSAIDs for rotator cuff tendinitis with shoulder pain had equivalent outcomes with those of steroid injection at the 12-week follow-up.

**Keywords:** Anti-inflammatory agents, non-steroidal; Impingement syndrome; Ketorolac; Rotator cuff injuries; Triamcinolone

## INTRODUCTION

The most common cause of shoulder pain is impingement syndrome in the subacromial space, which consists of the rotator cuff, bursa, and coracoacromial ligament [1]. Impingement between the humeral head and coracoacromial arch is associated

with osteophytes within the acromion, weakening of the rotator cuff, and mismatch of shoulder movements [2]. Various treatment modalities, including medication, physical therapy, intra-articular injection, and operative decompression, are used to treat impingement syndrome [3].

Intra-articular injections are easily performed in outpatients.

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Correspondence to: Jun-Sung Won

Department of Orthopedic Surgery, Veterans Health Service Medical Center, 53 Jinhwangdo-ro 61-gil, Gangdong-gu, Seoul 05368, Korea  
Tel: +82-2-2225-1352, Fax: +82-2-2225-1910, E-mail: 99korean@naver.com, ORCID: <https://orcid.org/0000-0002-5454-4877>

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Corticosteroids have been widely used in intra-articular injections for treatment of impingement syndrome because of their strong anti-inflammatory effects [4-8]. However, repeated use of steroids is not advisable due to resulting possible tears and weakening of the ligament or tendon in the shoulder, delayed healing, decrease in immunity, increased incidence of bacterial infection, and fluctuating blood glucose level [9-12].

Nonsteroidal anti-inflammatory drugs (NSAIDs) and platelet-rich plasma have been proposed as injectable options [13-15]. NSAIDs have been widely used, and their effectiveness in reducing pain and inflammation, in addition to their stability when administered orally or as intramuscular injections, has been demonstrated. Several authors have reported that an intra-articular ketorolac injection is effective and safe for articular cartilage, ligament, and joint function [14,16]. However, the exact method of injection and the effective dose are unknown.

The aim of this prospective, double-blinded study was to evaluate the short-term effect of subacromial injection of NSAIDs compared with the outcomes of steroid injections. If NSAIDs have effects equivalent to those of steroids, the adverse effects associated with steroids could be avoided with the use of NSAIDs. The exact method of injection for geriatric patients was established, and three established score systems were adopted for evaluation.

## METHODS

### Demographic Data

The data were obtained from patients with subacromial impingement syndrome who were treated at our medical center from March 2016 to December 2017, after approval from the Institutional Review Board (IRB No. 2016-03-019). Informed consent was received before data collection.

A randomized, prospective, case-control study was conducted. The sizes of the experimental group and control group were determined based on a previous study considering a change in visual analog scale (VAS) score for pain greater than 20% [17,18]. A power analysis was used to calculate the required sample size. Assuming an approximate normal distribution for the primary outcome measure and a standard deviation of 15 points, to detect a 15-point difference in the Constant-Murley Shoulder score between treatment groups at a 5% level of significance with 80% power. Allowing for some losses to follow up (5%), a minimum sample size of 30 patients was needed for each arm of the trial.

Patients were enrolled if all the following inclusion criteria were satisfied: shoulder pain for more than 3 months, shoulder pain while lifting the arm between 70° and 120°, and positive re-

sults either for Neer's test or Hawkins's test. The exclusion criteria were as follows: osteoarthritis, calcific tendonitis, visible fracture on shoulder radiographs, passive anterior elevation less than 90° or external rotation less than 20°, history of an injection in the shoulder within the last 6 months, or rotator cuff tear on magnetic resonance imaging (MRI). Patients with uncontrolled diabetes, past history of gastritis or treatment for gastric bleeding, contraindications to steroids or NSAIDs, or secondary benefits from accidents or insurance also were excluded.

The participants were divided into two groups (group N received an NSAID injection and group S received a steroid injection) according to the following randomization procedure. Thirty cards of groups A and B were placed and sealed in a box, and the patient selected a card without the examiner's knowledge. There were no differences in age, sex, duration of illness, diabetes, VAS score, American Shoulder and Elbow Surgeons (ASES) shoulder score, and University of California Los Angeles (UCLA) shoulder score between the two groups (Table 1).

### Treatment Method

A subacromial injection as indicated on the chosen card was administered with an opaque syringe in an injection room. The physicians who administered the injection were not involved in the rest of the study. One milliliter of ketorolac (ketorolac tromethamine 30 mg/mL) or 1 mL of steroid (triamcinolone 40 mg/mL) and 1 mL of lidocaine (2% lidocaine hydrochloride inj.) in an opaque syringe was administered depending on group.

With the patient sitting comfortably, the upper arm was placed in 10° abduction and 10° lifting. An assistant held the arm in position while the injection was administered. After sterilization with alcohol and povidone, a 5 mL syringe with a 21-G needle was filled with the drug, and the needle was advanced to the rear of the acromioclavicular joint, 2-3 cm from the lateral center of

**Table 1.** Patient demographics by injection group

Variable	Group N	Group S	p-value
Number	30	30	
Age (yr)	66.6 ± 6.0	68.8 ± 6.0	0.151
Sex (male:female)	19:11	22:8	0.405
Symptom duration (mo)	8.8 ± 7.2	7.4 ± 5.5	0.388
DM	5	4	0.718
VAS pain score	6.8 ± 0.4	6.9 ± 0.4	0.356
ASES score	33.1 ± 8.9	31.9 ± 8.7	0.595
UCLA score	40.0 ± 9.3	38.5 ± 9.0	0.706

Values are presented as mean ± standard deviation. Group N: ketorolac injection group, Group S: steroid injection group, DM: diabetes mellitus, VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons, UCLA: The University of California, Los Angeles.

the acromion, in the inferior direction. After aspiration to ensure that the needle was not inside a vessel, the injection was administered. If resistance was felt during the injection, the procedure was immediately stopped, the needle was changed, and the injection re-administered with absence of resistance. During the study, all patients were prescribed acetaminophen and were trained to perform stretching exercises at home. The stretching exercises comprised lift, external rotation, internal rotation, and adduction exercises to an extent such that resistance was felt, and the position was maintained for 10 seconds. This was repeated 20 times for each exercise, four times a day before breakfast, lunch, dinner, and going to bed.

### Assessment or Outcomes

Clinical evaluation was performed before treatment and at 3, 6, and 12 weeks after treatment. VAS pain, ASES, and UCLA scores were assessed [19]. Patient satisfaction was assessed at the final follow-up using a numeric scale, with one point indicating the highest level of dissatisfaction and 10 points indicating the highest level of satisfaction. A score of 8 or higher was considered satisfactory. Range of motion is included in the shoulder score. Also, function was considered more important than height of arm lift. Therefore, the study focused on shoulder score.

For statistical analysis, t-test, chi-square test, and Fisher's exact test were used with IBM SPSS ver. 22.0 (IBM Corp., Armonk, NY, USA), and statistical significance was set at  $p$ -value  $\leq 0.05$ .

## RESULTS

There were no differences in age, sex, duration of pain, VAS score, ASES score, and UCLA score between the two groups before treatment. VAS, ASES, and UCLA scores improved in both groups from week three to week 12 after treatment ( $p < 0.000$ ). In all patients, VAS score improved from 6.9 before treatment to 2.0, 1.2, and 1.1 at 3, 6, and 12 weeks after treatment, respectively. ASES score improved from 32.7 before treatment to 81.5, 87.6, and 88.5 at 3, 6, and 12 weeks after treatment, respectively. UCLA score improved from 16.0 before treatment to 29.7, 31.8, and 32.0 at 3, 6, and 12 weeks after treatment, respectively.

In the NSAID group, pain VAS score improved from  $6.8 \pm 0.4$  before treatment to  $1.8 \pm 1.7$ ,  $1.1 \pm 1.8$ , and  $0.9 \pm 1.8$  at 3, 6, and 12 weeks after treatment, respectively, and in the steroid group, VAS score improved from  $6.9 \pm 0.4$  before the treatment to  $2.2 \pm 1.7$ ,  $1.3 \pm 1.7$ , and  $1.3 \pm 2.1$  at 3, 6, and 12 weeks after treatment. There was no statistical difference between the two groups at each follow-up visit ( $p = 0.356$ ,  $p = 0.452$ ,  $p = 0.715$ ,  $p = 0.469$ ) (Table 2). ASES score in the NSAID group improved from  $33.1 \pm 8.9$  before

treatment to  $83.1 \pm 15.0$ ,  $88.1 \pm 16.2$ , and  $90.3 \pm 15.9$  at 3, 6, and 12 weeks after treatment respectively, and in the steroid group, it improved from  $31.9 \pm 8.7$  before treatment to  $80.1 \pm 15.3$ ,  $87.4 \pm 16.5$ , and  $87.0 \pm 20.1$  at 3, 6, and 12 weeks after treatment, respectively. There was no statistical difference between the two groups at each follow-up visit ( $p = 0.595$ ,  $p = 0.447$ ,  $p = 0.868$ ,  $p = 0.475$ ) (Table 2). UCLA score in the NSAID group improved from  $16.0 \pm 1.4$  before treatment to  $30.8 \pm 5.3$ ,  $32.4 \pm 5.3$ , and  $33.2 \pm 5.0$  at 3, 6, and 12 weeks after treatment, respectively, and in the steroid group, it improved from  $15.9 \pm 1.4$  to  $28.7 \pm 4.5$ ,  $31.2 \pm 4.9$ , and  $31.0 \pm 5.9$ . There was no statistical difference between the two groups at each follow-up visit ( $p = 0.706$ ,  $p = 0.111$ ,  $p = 0.367$ ,  $p = 0.144$ ) (Table 2). The average patient satisfaction score after injection in the steroid group was  $8.6 \pm 2.1$ , and that in the NSAID group was  $8.9 \pm 1.9$ ; there was no statistical difference between the two groups ( $p = 0.565$ ). Satisfactory results were obtained in 26 cases (86.7%) in the steroid group and 28 cases (93.3%) in the NSAID group. There was no statistical difference between the two groups ( $p = 0.671$ ).

There were no cases with shoulder infection after subacromial injection; however, in one case, diabetes remained uncontrolled for 1 month after corticosteroid injection, and two patients complained of facial flushing. The participant with uncontrolled diabetes was treated at the hospital's endocrine department. The diabetes was well controlled until before treatment, and the glycosylated hemoglobin (HbA1c) level was 6.2%. After 1 month, the diabetes was under control without a change in medication. Both

**Table 2.** Clinical scores by injection method

Variable	Group N	Group S	p-value
VAS pain score			
Pre-injection	$6.8 \pm 0.4$	$6.9 \pm 0.4$	0.356
3 wk	$1.8 \pm 1.7$	$2.2 \pm 1.7$	0.452
6 wk	$1.1 \pm 1.8$	$1.3 \pm 1.7$	0.715
12 wk	$0.9 \pm 1.8$	$1.3 \pm 2.1$	0.469
ASES score			
Pre-injection	$33.1 \pm 8.9$	$31.9 \pm 8.7$	0.595
3 wk	$83.1 \pm 15.0$	$80.1 \pm 15.3$	0.447
6 wk	$88.1 \pm 16.2$	$87.4 \pm 16.5$	0.868
12 wk	$90.3 \pm 15.9$	$87.0 \pm 20.1$	0.475
UCLA score			
Pre-injection	$16.0 \pm 1.4$	$15.9 \pm 1.4$	0.706
3 wk	$30.8 \pm 5.3$	$28.7 \pm 4.5$	0.111
6 wk	$32.4 \pm 5.3$	$31.2 \pm 4.9$	0.367
12 wk	$33.2 \pm 5.0$	$31.0 \pm 5.9$	0.144

Values are presented as mean  $\pm$  standard deviation.

Group N: ketorolac injection group, Group S: steroid injection group, VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons, UCLA: The University of California, Los Angeles.

cases of facial flushing were women, and symptoms persisted for one week and improved without any treatment.

## DISCUSSION

This randomized, controlled, comparative study showed that ketorolac 30 mg/mL was not inferior to steroids as a subacromial injection for pain relief in patients with subacromial impingement syndrome. VAS pain, ASES, and UCLA scores were not different between the two groups, and the adverse effects of steroids were avoided using ketorolac.

The advantage of ketorolac is that its half-life is 150 minutes, which is longer than 88 minutes in triamcinolone, and is expected to be more effective for anti-inflammatory action [18]. Systemic adverse effects and stability of NSAIDs such as ketorolac administered as intramuscular and intravascular injections are well-known. The risks of intra-articular injection are not widely known; however, in animal experiments on rats and rabbits, intra-articular injection of NSAIDs did not cause cartilaginous changes, indicating its relative safety [16,20].

The most common adverse effect of steroids is flushing of the face, reported in 40% of patients [21]. In this study, two of 30 patients experienced flushing, both females, and the symptom resolved after 1 week without additional treatment. However, as the probability of recurrence of flushing during repeat injection is reported to be up to 100%, it is important to monitor patient discomfort closely and to prevent recurrence of the same adverse effects [21].

Topical corticosteroid injections can lead to elevated blood glucose level in diabetic patients [11]. In this study, blood glucose remained uncontrolled in one case but improved after 1 month without a change in medication. Additional tests showed no significant increase in glycated hemoglobin level; nevertheless, special attention and care are needed.

Three or more repeated corticosteroid injections increase the rate of suture failure by decreasing the tendon suture displacement strength during rotator cuff repair surgery [22]. However, there is no evidence of absence of reduction in suture displacement strength with NSAIDs. Nevertheless, since there is no report of muscular atrophy after intramuscular injection of NSAIDs, they are thought to be safer than steroids. According to Almekinder et al. [23], NSAIDs have a positive effect on the maturation and reforming stages of tendon healing.

Limitations of using NSAIDs include the probability of decreased renal function and gastritis. However, in cases of subacromial impingement, they are not used continuously, unlike when taken as oral medications for other conditions. Moreover, a

topical injection is thought to have a less severe effect on renal function compared to oral administration.

Another limitation is the possibility that adhesive capsulitis cases were included in the study. Patients with less than 90° of anterior elevation and less than 20° of external rotation were excluded, but not all patients with stiff shoulder were excluded. However, it is not expected that there will be a significant impact on the results.

In this study, the follow-up period was short (3 months); hence, the long-term effectiveness and adverse effects of treatment were not assessed. Furthermore, we were unable to investigate the status of the rotator cuff using MRI or arthroscopy in many patients. However, conservative therapy can be administered as an initial treatment for a rotator cuff tear, which does not cause any harm, such as a delay in treatment, and is thought to be clinically useful. Another limitation is that ultrasonography was not used to guide subacromial injections, which might affect the accuracy of the location of injections. Finally, the patients were instructed to perform exercises at home. These are important for conservative treatment but could not be verified in all patients. Since the treatment result was satisfactory, high compliance was assumed.

Another limitation is that the effects of acetaminophen cannot be controlled. However, in patients with subacromial impingement syndrome, acetaminophen is commonly administered as a subacromial injection to reduce pain and is not a problem for clinical use. Despite these limitations, the strengths of the study include no loss of participants due to dropout and absence of associated errors. In treatment of subacromial impingement syndrome, subacromial injection of Ketorolac 30 mg was equivalent to corticosteroid injection in terms of effectiveness. In patients with diabetes or those who have concerns about the adverse effects of steroids, subacromial injection of Ketorolac can be considered a suitable alternative.

## ORCID

Youngbea B Kim

<https://orcid.org/0000-0003-3966-0949>

Jun-Sung Won

<https://orcid.org/0000-0002-5454-4877>

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# Long-term outcomes of initially conservatively treated midshaft clavicle fractures

Gwan Bum Lee, Hyojune Kim, In-Ho Jeon, Kyoung Hwan Koh

Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea

**Background:** Recent studies about completely displaced midshaft clavicle fractures have reported that their nonunion/malunion rates were significantly higher in conservatively treated patients compared to surgically treated patients. The purpose of this study was to evaluate the factors associated with treatment decisions for midshaft clavicle fractures and also the factors that affect patient satisfaction with their treatment choice.

**Methods:** We retrospectively reviewed the records of 75 patients who had been diagnosed with a midshaft clavicle fracture and were treated conservatively at a single institution between March 1, 2013, and December 31, 2014. Their medical records were reviewed to investigate the severity of the initial vertical displacement. A telephone survey was carried out to identify the presence of any patient-perceived deformity and determine if the patient eventually underwent surgery and whether the patient would prefer surgery if the injury recurred.

**Results:** Significantly more patients with vertical displacement  $\geq 100\%$  (9/28) eventually underwent surgery compared to patients with vertical displacement  $< 100\%$  (3/32,  $p=0.028$ ). Patients with vertical displacement  $\geq 100\%$  (13/28) were significantly more likely to prefer surgery compared to patients with vertical displacement  $< 100\%$  (7/32,  $p=0.044$ ). Among the conservatively treated patients, nine of 32 participants with a patient-perceived deformity and one of 16 without a patient-perceived deformity responded that they would prefer to receive surgery in same situation in the future ( $p=0.079$ ).

**Conclusions:** Patients with a midshaft clavicle fracture with vertical displacement of  $\geq 100\%$  may eventually require surgical treatment. When conservative treatment is carried out, the long-term patient results may be unsatisfactory due to perceived residual deformities.

**Keywords:** Mid-shaft clavicle fracture; Conservative treatment; Shared decision-making; Deformity; Vertical displacement

## INTRODUCTION

Clavicle fracture is a common injury, with midshaft fractures accounting for about 80% of all clavicle fractures [1,2]. In the 1960s, Neer [3] and Rowe [4] reported a nonunion rate of 0.1–0.7% in conservatively treated midshaft clavicle fractures.

Since then, most midshaft clavicle fractures have been treated effectively with conservative approaches using an arm sling or figure-of-eight bandage [5]. Recent studies have not reported significant differences in the functional outcomes between conservative and surgical treatments for displaced midshaft clavicle fractures. However, the nonunion/malunion rates have been sig-

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Correspondence to: Kyoung Hwan Koh

Department of Orthopedic Surgery, Asan Medical Center, University of Ulsan College of Medicine, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea

Tel: +82-2-3010-3530, Fax: +82-2-488-7877, E-mail: [osdoc.koh@gmail.com](mailto:osdoc.koh@gmail.com), ORCID: <https://orcid.org/0000-0002-6181-9621>

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nificantly higher in patients treated conservatively [6-8], especially those with completely displaced midshaft clavicle fractures with a displacement of  $\geq 100\%$ , where a 15%–20% nonunion rate has been reported [9,10].

These recent long-term outcomes of increased nonunion/malunion rates after conservative treatment have changed the indications for surgery when treating midshaft clavicle fractures. However, if the long-term functional outcome is not significantly different between conservative and surgical treatments and both treatment methods provide good outcomes, other factors may also be needed to aid in decision-making. Because both treatment methods have their own pros and cons, clinicians must consider not only the long-term outcome of the treatment methods, but also the patient's condition and the discomfort experienced at the time of injury or the expected satisfaction with the final outcome of the treatment. Further, shared decision-making after sufficient consultation between patient and surgeon can lead to better outcomes when selecting treatment plans for orthopedic conditions [11].

We wondered if any factors present at the time of injury were associated with the patient's decision to proceed with surgical treatment. We also investigated if there were common characteristics among patients who were satisfied with their treatment method. The objective of this study was to investigate the hypothesis that patients with midshaft clavicle fracture with a displacement of  $\geq 100\%$  will eventually undergo surgical treatment and will be satisfied with the surgical treatment.

## METHODS

All procedures performed in studies involving human participants were carried out in accordance with the ethical standards of the Institutional Review Board of Asan Medical Center (IRB No. 2018-1091), and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

### Patients and Study Design

We retrospectively reviewed the medical records of patients who were diagnosed with a midshaft clavicle fracture in the outpatient clinic and emergency department of Asan Medical Center in Seoul, South Korea, between March 1, 2013 and December 31, 2014.

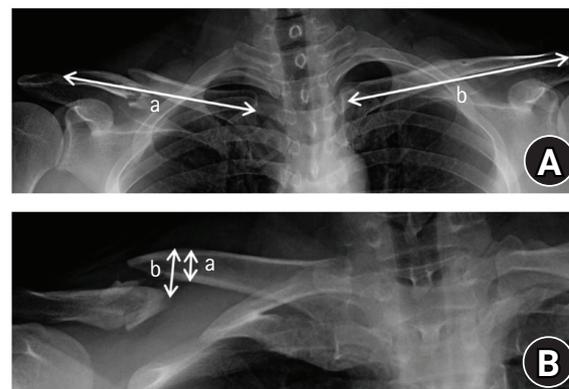
During the eligibility period, we identified 81 patients from 19 to 70 years of age who were diagnosed with a midshaft clavicle fracture. We excluded five patients who had been previously

treated for fracture of the ipsilateral clavicle and one patient who underwent surgical treatment at the time of injury due to other concomitant fractures. The patients were treated conservatively with either an arm sling or a figure-of-eight bandage regardless of any comminution and segmentation of the fracture. These patients were informed that surgical treatments should be considered if the displacement of the fracture increases, if pain persists for more than 6 months from the time of fracture, or if nonunion occurs during the follow-up period. An arm sling or figure-of-eight bandage was used for 6 weeks; tolerable range of motion was allowed, while excessive motion was restricted. Patients were referred to their local primary hospital for regular follow-up. These patients were instructed to re-visit our clinic if a change in treatment plan was needed.

In May 2018, we reviewed the medical records of the 75 eligible patients to investigate their age at the time of injury, sex, dominant arm, side of injury (right or left), injury mechanism, and any other concomitant injuries and medical comorbidities. We reviewed the initial radiographs of all patients and then conducted a telephone survey to evaluate the clinical results at the time of the study.

### Radiological Evaluation

Clavicle fractures were classified according the *Arbeitsgemeinschaft für Osteosynthesefragen (AO) Fracture and Dislocation Classification Compendium*, which was revised in 2018 [12]. Shortening of the clavicle was defined as the difference between the intact clavicle length and the injured clavicle length as measured on an anteroposterior X-ray. Vertical displacement was assessed by dividing the distance between the superior cortex of



**Fig. 1.** The radiologic assessment of the initial X-ray of a patient with a midshaft clavicle fracture. (A) The calculation method for shortening the clavicle length from both clavicle anteroposterior view X-rays: the length of the contralateral clavicle (b)–the length of the fractured clavicle (a) (mm). (B) The calculation method for vertical displacement of the clavicle on a 30° cephalic tilt view X-ray: cortical displacement (b)/one bone width of the clavicle (a)×100 (%).

both fractured fragments by one bone width of the injured clavicle on a 30° cephalic tilt view X-ray (Fig. 1) [13,14]. Patients were classified according to the presence or absence of cortical contact.

### Clinical Survey

In May 2018, 60 of the 75 eligible patients participated in a telephone survey. Patients with pain or other discomfort were encouraged to visit our clinic for further evaluation and counseling. In the telephone survey, the patients were asked whether they eventually received surgery at our hospital or another clinic. For those who underwent surgery, questions about why and when it had taken place were also asked. Patients were also queried about any complications after the surgery and the presence of discomfort or a patient-perceived subjective deformity.

We also verified whether the patient had a confirmation of union from the treating hospital. As part of the clinical assessment, the American Shoulder and Elbow Surgeons (ASES) and pain numeric rating scale (NRS) scores at the time of the telephone survey were also assessed [15]. If the patients complained about pain near the glenohumeral joint area, the degree of pain around the clavicular area was reassessed to differentiate it from other pain due to glenohumeral joint disease. The telephone surveys were performed by a physician who was not involved in treating the patients. Finally, the patients were asked if they would or would not elect to receive surgery again if they were in same situation of clavicle fracture, and the main reason for their answer was recorded.

### Statistical Analysis

To analyze the factors associated with the decision to choose surgical treatment, variables including age, sex, involvement of the dominant arm, AO classification, vertical displacement distance, and amount of shortening were included in the univariate analysis (chi-square test for categorical variables and t-test for continuous variables). Variables with a p-value < 0.2 upon univariate analysis were included in the multivariable logistic regression analysis. A p-value < 0.05 was considered statistically significant.

## RESULTS

An analysis of the differences in clinical and radiological parameters between patients who initially received operative treatment and those who received conservative treatment is shown in Table 1. There were no significant differences between the two groups in age, sex, involvement of the dominant arm, in-

**Table 1.** Clinical and radiological data of patients with midshaft clavicle fracture

Variable	Operative treatment	Conservative treatment	p-value
Number	12	48	
Sex (male:female)	9:3	40:8	0.505
Age (yr)	44.2	46.3	0.668
Dominant arm involvement, n (%)	5 (41.7)	22 (45.8)	0.795
Injury mechanism			0.781
Motorcycle TA	1	4	
In car TA	2	5	
Pedestrian TA	0	2	
Slip down	8	34	
Fall from a height	0	2	
Others	1	1	
AO classification			0.719
Simple	6	20	
Wedge	3	18	
Multi-fragmentary	3	10	
Shortening (mm)	-7.8	-3.7	0.185
Displacement (%)	126.3	90.9	0.095
Displacement			0.028*
< 100%	3	29	
≥ 100%	9	19	
Reason for operation			
Doctor's opinion	6		
Pain	4		
Nonunion	1		
Others	1		
Time to operation			
< 1 wk	11		
> 6 mo	1		
Postoperative complication			
Implant irritation	1		
Nonunion	1		
Wound problem	1		

TA: traffic accident, AO: arbeitsgemeinschaft für osteosynthesefragen. \*p<0.05.

jury mechanism, or AO classification (Table 1).

There was no significant difference in the average clavicle shortening distance in patients who received operative treatment (7.8 mm) and in patients who received conservative treatment (3.7 mm, p=0.185). There was also no significant difference in the mean vertical displacement between patients who underwent operative treatment (126.3%) and patients who received conservative treatment (90.9%, p=0.095). Significantly more patients (9/28, 32.1%) with vertical displacement > 100% underwent operative treatment than patients (3/32, 9.4%) with vertical displacement < 100% (p=0.028) (Table 1).

In the telephone survey, significantly more patients (32/48, 66.7%) reported a subjective deformity after receiving conservative treatment than patients (2/12, 16.7%) who initially underwent operative treatment ( $p=0.002$ ). There was no significant difference in the number of patients with a confirmed union ( $P>0.999$ ), ASES score ( $p=0.784$ ), or a pain NRS score ( $p=0.795$ ) between participants who underwent operative treatment and those who received conservative treatment (Table 2).

When responding to the question about whether the patient would choose to undergo surgery in the same situation of clavicle fracture in the future, 10 of 48 (20.8%) respondents who initially received conservative treatment answered that they would choose surgery instead. The main reasons for that answer were delayed union or nonunion in four patients, a patient-perceived deformity in five patients, and remaining pain in one patient. More patients (10/12, 83.3%) who had undergone surgery responded that they would choose surgery again if presented with the same situation than patients who received conservative management (10/48, 20.8%;  $p<0.001$ ). Significantly more patients (13/28, 46.4%) with vertical displacement  $>100\%$  responded that they would elect for surgery again if in the same situation than patients (7/32, 21.9%) with vertical displacement  $<100\%$  ( $p=0.044$ ) (Table 3).

In the analysis of patients who received conservative treatment, five of 19 (26.3%) participants with vertical displacement  $>100\%$  and five of 29 (17.2%) patients with vertical displacement  $<100\%$  responded that they would elect for surgery in the same situation again; this result had no significance difference ( $p=0.449$ ). Significantly fewer patients (7/44, 15.9%) with confirmed union responded that they would elect to have surgery again in the same situation than patients (3/4, 75%) with nonunion ( $p=0.005$ ). Nine of 32 (28.1%) patients with a patient-perceived deformity and one of 16 (6.25%) without a patient-perceived deformity responded that they would choose surgery if in the same situation, which showed no significant difference ( $p=0.079$ ).

Variables with  $p$ -values  $<0.2$  upon univariate analysis of patient willingness to opt for surgery in the same situation included the following: "previous treatment method" ( $p<0.001$ ), "vertical displacement" ( $p=0.044$ ), and "confirmation of union" ( $p=0.186$ ) (Table 3). A multiple logistic regression analysis was performed using these three variables. "Treatment method" ( $p=0.001$ ) significantly influenced the decision to undergo an operation in the same future situation, but "vertical displacement" ( $p=0.246$ ) and "confirmation of union" ( $p=0.114$ ) were not significantly associated.

**Table 2.** Telephone survey results

Variable	Operative treatment	Conservative treatment	p-value
Union			1.000
Yes	11	44	
No	1	4	
Patient-perceived deformity			0.002*
Yes	2	32	
No	10	16	
ASES score	92.4	93.6	0.784
Pain (NRS) score	0.5	0.4	0.795

ASES: American Shoulder and Elbow Surgeons, NRS: numeric rating scale.

\* $p<0.05$ .

**Table 3.** Patient willingness to elect surgery in the same situation

Variable	Yes	No	p-value
Treatment method			$<0.001^*$
Operative	10	2	
Conservative	10	38	
Displacement			0.044*
$<100\%$	7	25	
$\geq 100\%$	13	15	
Union			0.186
Yes	17	38	
No	3	2	
Patient-perceived deformity			0.854
Yes	11	23	
No	9	17	

\* $p<0.05$ .

## DISCUSSION

Patients with midshaft clavicle fracture and a vertical displacement of  $\geq 100\%$  were more likely to eventually undergo surgical treatment than patients with a vertical displacement  $<100\%$ . Of the 12 patients who had undergone conservative treatment first but eventually received surgery, four chose surgery due to severe pain caused by the fracture. When the vertical displacement is large, any fragments can irritate the skin and periosteum, resulting in greater pain and discomfort [16]. However, due to our small sample size and retrospective study design, we could not analyze the statistical difference in the degree of subjective pain at the initial trauma between the conservative treatment group patients and the operative treatment group patients. Further studies with larger sample sizes that consider this subjective pain as a factor in decision-making will be required.

A substantial number of patients who underwent conservative

treatment responded that they would elect for surgery instead if presented with the same situation. This finding likely resulted not only from the presence of nonunions but also patient-perceived deformities or persisting pain until union is achieved, which can result when conservative treatment is chosen as the initial treatment method.

In our study, patients who had undergone surgery had a tendency to respond that they would elect for surgery if faced with the same situation in the future, while patients who had undergone conservative treatment the first time around had a tendency to respond that they would select conservative treatment again. In other words, patients tend to regard the previous treatment method as the correct decision and are likely to select the same method if they experience a similar future injury. However, patients with vertical displacement of  $\geq 100\%$  were significantly more likely to report that they would prefer surgery if they were to experience a similar injury compared to patients who experienced a vertical displacement of  $< 100\%$ .

In the analysis of patients who received conservative treatment, patients with nonunion were significantly more likely to prefer surgery if in the same situation in the future, while patients with a perceived deformity had a tendency (that was not statistically significant) to respond that they would elect for surgery if they ever faced the same situation. This result is in line with previous reports about the consequences of conservative treatment in vertically displaced midshaft clavicle fractures [5,17]. Based on these results, patient-perceived deformity and nonunion of the fracture are likely the most important factors to patients following treatment and affect the satisfaction of patients regarding their fracture treatment method.

Patients with midshaft clavicle fracture with an initial vertical displacement of  $\geq 100\%$  are more likely to eventually undergo surgical treatment due to acute pain, severe deformity, or another doctor's second opinion. Although there may be no functional deficits, deformity and nonunion may occur in those who choose conservative treatment; therefore, these patients may not be satisfied with their fracture treatment method after some time has passed. This information can be helpful for surgeons and patients when making shared decisions about treatment.

This study had an inherent weakness due to its retrospective study design and small sample size. In addition, the telephone survey did not allow us to confirm the union status of the fracture site with a radiographic examination, and we also could not assess the exact residual deformity of the clavicle (including shortening and angulation) radiographically. Finally, because only the subjective patient-reported outcomes were evaluated by telephone survey, we were unable to conduct an objective evalua-

tion in person and therefore could not objectively assess the long-term outcomes. However, we were able to obtain responses from about 80% of patients, and non-responders did not differ in their demographic characteristics (such as age or sex) from the responders. Because the objective of our study was to determine the factors that influence the treatment strategy selection at the time of trauma, the initial radiographic analysis was sufficient to proceed with our study.

Patients who receive conservative treatment for midshaft clavicle fracture with a vertical displacement of  $\geq 100\%$  may eventually require surgical treatment. If conservative treatment is continued, the patients may be relatively dissatisfied with any residual subjective deformity even though there may be no functional deficit or decrease in union rate compared to patients who initially received surgery.

## ORCID

Gwan Bum Lee	<a href="https://orcid.org/0000-0003-4471-0103">https://orcid.org/0000-0003-4471-0103</a>
Hyojune Kim	<a href="https://orcid.org/0000-0001-7665-536X">https://orcid.org/0000-0001-7665-536X</a>
In-Ho Jeon	<a href="https://orcid.org/0000-0002-9289-9193">https://orcid.org/0000-0002-9289-9193</a>
Kyoung Hwan Koh	<a href="https://orcid.org/0000-0002-6181-9621">https://orcid.org/0000-0002-6181-9621</a>

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# Evaluation of acromial spur using ultrasonography

Hyungsuk Kim, Syungkyun Choi, Soo Bin Park, Hyun Seok Song

Department of Orthopedic Surgery, Eunpyeong St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

**Background:** The presence of an acromial spur implies a rotator cuff disorder due to impingement between the acromial spur and the rotator cuff. The purpose of the study was to observe acromial spurs using ultrasonography and to compare measurements between plain radiographs and sonograms.

**Methods:** We retrospectively enrolled 51 consecutive patients with acromial spurs, which were interpreted on preoperative plain radiographs (supraspinatus outlet view and 30° caudal tilt) and preoperative sonograms. The ultrasonography transducer was held vertically and continuously moved laterally, which corresponded to the long axis of the long head of the biceps. The distance from the most distal margin of the original acromion to the most projected point of the acromial spur was measured.

**Results:** No significant difference was found between the plain radiograph and ultrasonography measurements ( $p=0.186$ ). A moderate to strong correlation was detected between the ultrasonography and supraspinatus outlet-view measurements ( $r=0.776$ ,  $p=0.000$ ).

**Conclusions:** Anteriorly projected acromial spurs were well-visualized by ultrasonography. No discrepancy in acromial spur length was detected between the use of plain radiography (supraspinatus outlet view and 30° caudal-tilt view) and ultrasonography. The correlation coefficients between the plain radiography and ultrasonography measurements exceeded 0.7.

**Keywords:** Shoulder; Acromial spur; Ultrasonography

## INTRODUCTION

Acromial spurs are a common finding in patients with shoulder pain and are known to be an extrinsic factor that can trigger rotator cuff disorders [1]. The presence of an acromial spur implies the existence of a rotator cuff disorder due to impingement between the acromial spur and the rotator cuff. Numerous studies have reported a relationship between acromial spurs and rotator cuff disorders and larger acromial spurs are reported to be an important defining factor in success with the diagnosis and treat-

ment of rotator cuff tears in patients with shoulder pain [1-3].

Acromial spurs are usually detected on plain radiographs. Bigliani et al. [1] classified the acromion, based on the shape of its undersurface on supraspinatus outlet-view radiographs, as follows: type I (flat), type II (curved), and type III (hooked). Type III acromion is strongly associated with rotator cuff tears. Kitchel [4] subsequently introduced the 30° caudal-tilt view to evaluate the anterior acromion. Later, Ono et al. [5] reported a close correlation between arthroscopic findings for acromial spur and those obtained using the 30° caudal-tilt view.

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Correspondence to: Hyun Seok Song

Department of Orthopedic Surgery, Eunpyeong St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 1021 Tongil-ro, Eunpyeong-gu, Seoul 03312, Korea

Tel: +82-2-2030-4628, Fax: +82-2-2030-4629, E-mail: [hssongmd@hanmail.net](mailto:hssongmd@hanmail.net), ORCID: <https://orcid.org/0000-0002-7844-2293>

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Due to its noninvasiveness and cost-effectiveness, ultrasonography is a useful diagnostic method for patients with shoulder pathology [6,7]. Ultrasonography can be used to obtain multiplanar images of fractures around the shoulder joint, while plain radiography only provides a two-dimensional view of the area of interest. Fractures of the coracoid process, greater tuberosity, and scapula are readily detected by ultrasonography, whereas they occasionally go undetected on plain radiographs [8,9]. Acromial spur, by its osseous nature, can also be easily detected using ultrasonography. By offering real-time images and the ability to recreate a shoulder-impingement condition, ultrasonography can provide meaningful clinical information regarding the relationship between the acromial spur and symptoms. However, to our knowledge, no study has yet diagnosed or measured acromial spurs using ultrasonography.

The purpose of the study was therefore to observe acromial spurs using ultrasonography and to compare measurements thereof between plain radiographs and sonograms. A close correspondence between plain radiography and ultrasonography spur measurements was expected. The hypotheses of our study were that the anteriorly projected acromial spurs would be well-visualized by ultrasonography and the lengths of the spur as measured using ultrasonography and plain radiography, respectively, would be comparable.

## METHODS

This study protocol was approved by the Institutional Review Board of Eunpyeong St. Mary's Hospital (IRB No. PIRB-20190801-009), which waived the requirement for informed consent due to the retrospective nature of the study.

### Patient Enrollment

Routine preoperative ultrasonography data from 95 patients who

underwent arthroscopic acromioplasty with rotator cuff repair were retrospectively reviewed. Among these 95 patients, only those patients documented to have confirmed acromial spur on both ultrasonography and plain radiography were enrolled, resulting in a total of 51 consecutive study participants. Patients with fractures, infections, tumors, or labral disorders, including instability, were excluded. All surgeries were performed at a single university hospital by a senior shoulder surgeon.

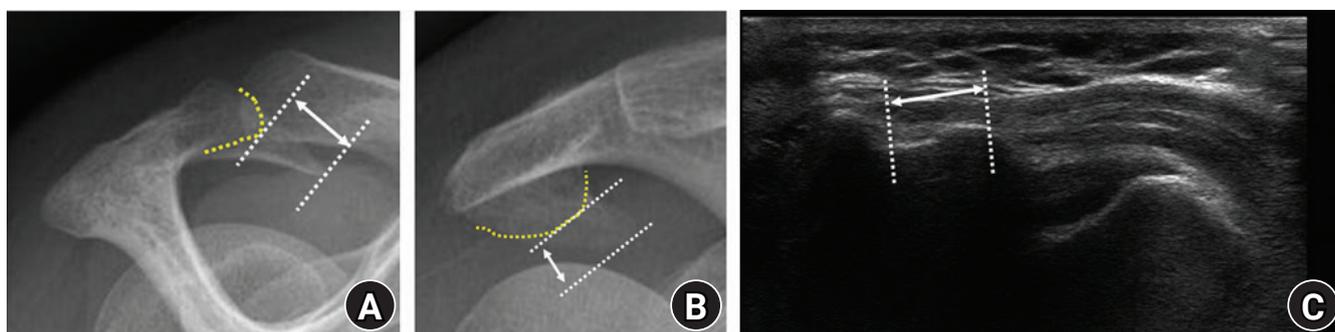
### Radiological Assessment of the Acromial Spur

The acromial spur was analyzed in both the supraspinatus outlet view and the 30° caudal-tilt view on plain radiographs. The length from the anterior acromion to the most projected point of the acromial spur was measured in the supraspinatus outlet view and 30° caudal-tilt view. All measurements were performed by two orthopedic surgeons (HSS and HK) and were made with a picture archiving and communication system (Marosis M-view ver. 5.4; Marotech, Seoul, Korea) (Fig. 1).

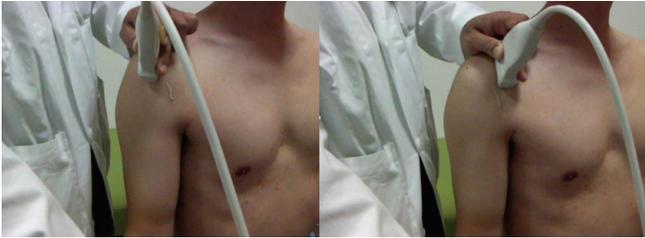
### Ultrasonography Assessment of the Acromial Spur

Preoperative ultrasonography was performed and real-time images were obtained with a linear 1- to 15-MHz transducer (Philips HD11 XE; Philips Medical Systems, Andover, MA, USA). All ultrasonography examinations were performed by the same senior shoulder surgeon (HSS), with the patient sitting on a chair and the examiner standing behind the patient. During the assessment, the patient's shoulder was positioned in a neutral position, with the elbow flexed and hand supinated, to allow examination of the acromial spur. The transducer was held vertically and continuously moved laterally to medially, which corresponded to a range from the long axis of the long head of the biceps to the short axis of the subscapularis (Fig. 2). The ultrasonography images were saved as videos for analysis.

Still images were obtained when the acromial spur was most



**Fig. 1.** Right shoulder of a 59-year-old woman. (A) The length (arrow) from the anterior acromion (yellow dotted line) to the most projected point of the acromial spur was measured on supraspinatus outlet-view radiographs. (B) The length (arrow) from the most distal margin of the original acromion (yellow dotted line) to the most projected point of the acromial spur was measured on 30° caudal-tilt view radiographs. (C) Length of the acromial spur (arrow) measured on a sonogram.



**Fig. 2.** The transducer was held vertically during ultrasonography and continuously moved laterally to medially, which corresponded to a scan of the long axis of the long head of the biceps to the short axis of the subscapularis.

visible in the ultrasonography videos and the distance from the anterior margin of the acromion to the most distal point of the acromial spur was measured on said still images (Fig. 1C). All measurements were performed by two orthopedic surgeons (HSS and HK), who were blinded to the diagnosis and interpreted the measurements independently of one another.

### Statistical Analysis

Repeated-measures analysis of variance was used to compare the supraspinatus outlet view, 30° caudal-tilt view, and ultrasonography measurements of the distance from the anterior margin of the acromion to the most distal point of the acromial spur. The paired t-test was used to compare the measured distances between the supraspinatus outlet view and the 30° caudal-tilt view, the supraspinatus outlet view and sonogram, and the 30° caudal-tilt view and sonogram, respectively. A simple correlation analysis was used also performed to compare the collected measurements between the imaging modalities. IBM SPSS ver. 24.0 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. Significance levels for all analyses were set at  $p < 0.05$ .

## RESULTS

### Patient Demographics

The mean age of the patients was 60.6 years (range, 36–78 years) and 29 of 51 patients were women (56.9%). The dominant shoulder was affected in 42 cases (82.4%). One patient who underwent bilateral surgery was also enrolled, so 52 cases were included in the final analysis.

All patients had at least one pathology in the supraspinatus, subscapularis, and/or long head of the biceps. In total, 48 patients (92.3%) had pathologies in the supraspinatus tendon, including 35 (67.3%) with full-thickness tears and 13 (25%) with partial-thickness tears. Meanwhile, there were 28 patients (53.8%) with pathologies in the subscapularis tendon, including one (1.9%) with a full-thickness tear and 27 (51.9%) with par-

tial-thickness tears. Finally, 28 patients (53.8%) had pathologies in the biceps long head tendon, including six (11.5%) with total tendon rupture and 22 (42.3%) with partial tendon rupture.

### Comparison of Measurements

The mean acromial spur length, as measured in the supraspinatus outlet view, was  $4.2 \pm 3.7$  mm, while that in the 30° caudal-tilt view was  $4.8 \pm 3.9$  mm. No significant difference was found between the plain radiograph (supraspinatus outlet view and 30° caudal-tilt view) and ultrasonography measurements ( $p = 0.186$ ); however, a significant difference was found between the two plain radiographs ( $p = 0.008$ ). Meanwhile, no significant difference was found between the ultrasonography and supraspinatus outlet-view measurements ( $p = 0.363$ ) or between the ultrasonography and 30° caudal-tilt view measurements ( $p = 0.451$ ).

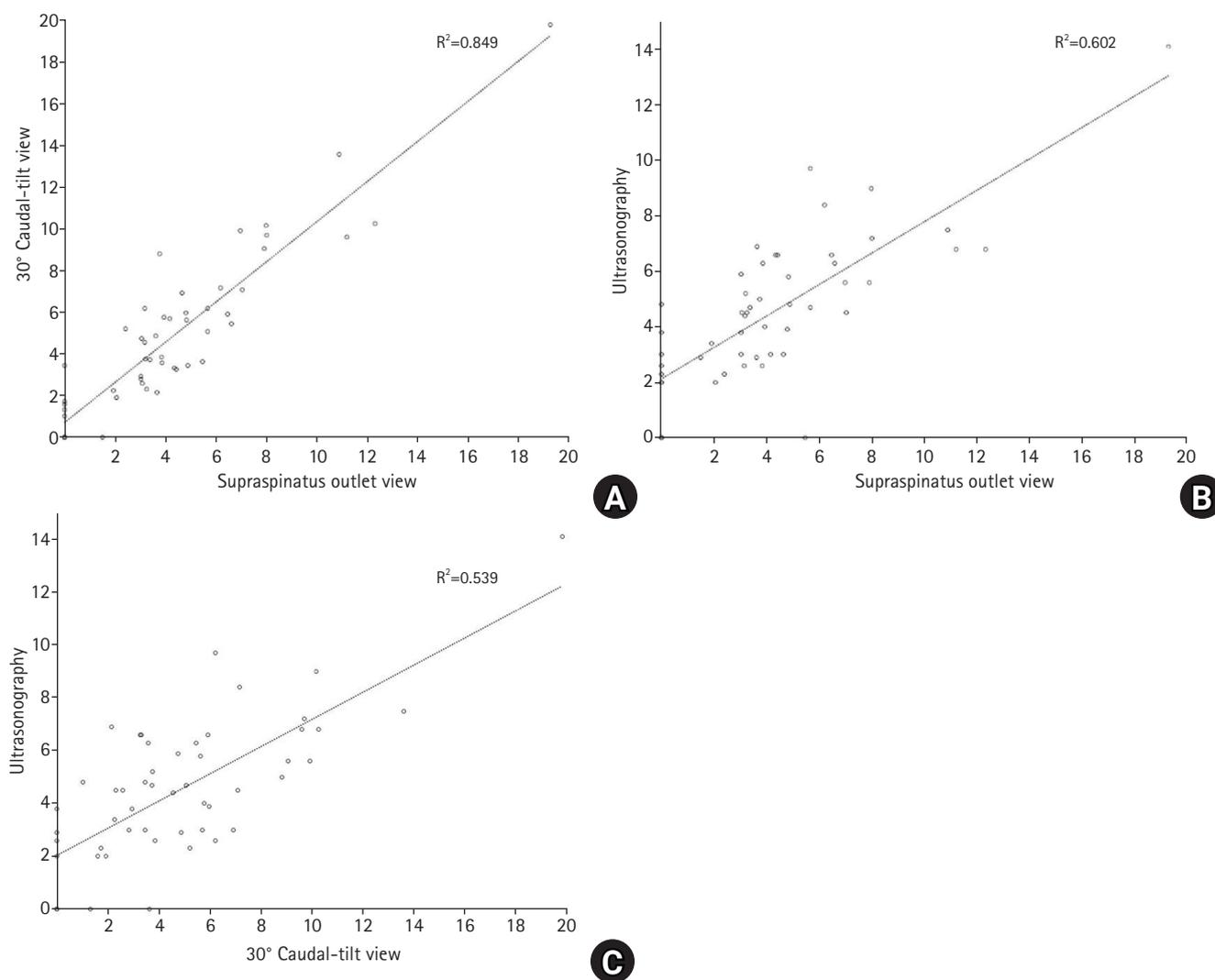
A strong correlation was detected between the supraspinatus outlet view and 30° caudal-tilt view measurements ( $r = 0.922$ ,  $p = 0.000$ ), while a moderate to strong correlation was observed between the ultrasonography and supraspinatus outlet-view measurements ( $r = 0.776$ ,  $p = 0.000$ ) and between the ultrasonography and 30° caudal-tilt view measurements ( $r = 0.734$ ,  $p = 0.000$ ). A scattered plot of the plain radiograph and ultrasonography measurements is shown in Fig. 3.

## DISCUSSION

In this study, no significant difference was found in the length of the acromial spur when using plain radiography (supraspinatus outlet view and 30° caudal-tilt view) versus ultrasonography. Moreover, a strong correlation was observed between the plain radiography and ultrasonography measurements.

The morphology of the acromion attracted attention following the introduction of impingement theory for rotator cuff tear by Neer [10]. Bigliani et al. [1] classified the acromion by shape and many subsequent studies have since reported that their type III acromion is associated with rotator cuff tears [11,12]. However, the reliability of the classification system by Bigliani et al. [1] remains controversial due to low interobserver reliability and the relatively poor image quality of plain radiographs [13,14].

An acromial spur forms due to traction of the coracoacromial ligament. Although the etiology of rotator cuff tears is unclear, acromial spurs are convincing as a causative factor. Several imaging studies and cadaveric studies have reported acromial spur as a degenerative change that can lead to tearing of the rotator cuff [15-17]. Ogawa et al. [2] classified acromial spurs by length, as measured in the supraspinatus outlet view, and reported that spurs measuring more than 5 mm have diagnostic value for the



**Fig. 3.** Scattered plot showing a moderate correlation between plain radiography and ultrasonography measurements. (A) Supraspinatus outlet view and 30° caudal-tilt view. (B) Supraspinatus outlet view and ultrasonography. (C) Thirty-degree caudal-tilt view and ultrasonography.

occurrence of rotator cuff tear. Tucker and Snyder [3] introduced the concept of keel spurs, which resemble a sailboat keel; such spurs may be observed on the undersurface of the acromion on plain radiographs. Further, they theorized that patients with a keel spur are at significant risk of bursal sided partial-thickness and full-thickness rotator cuff tears. For such reasons, acromioplasty is commonly performed during rotator cuff repair and also as a part of subacromial bursectomy [18]. Ono et al. [5] used the 30° caudal-tilt view to evaluate an anteriorly prominent acromial spur. Inferiorly projecting spurs can be visualized more easily by tilting the X-ray beam 30° superior to inferior. Both the supraspinatus outlet view and 30° caudal-tilt view were adopted in this study.

As imaging modalities and arthroscopic techniques have progressed, acromial spurs can now be classified based on computed tomography (CT), magnetic resonance image (MRI), and ar-

throscopic findings. Oh et al. [19] classified acromial spurs based on their shape and thickness revealed by plain radiography and MRI arthrography or CT arthrography. In their study, acromial spurs were classified into six types. The heel spur was the most common type in their rotator cuff tear group; the mean acromial thickness in their cohort was 8.0 mm, but was thicker in the rotator cuff tear group. Kongmalai et al. [20] classified acromial spurs based on 30° caudal-tilt view and arthroscopic findings, where keel spur was the most common finding, followed by heel spur. These authors [20] described patients with either of these spur types as “being at-risk” of a supraspinatus tendon tear. In our study, laterally protruding or medial-type spurs on the short axis of the subscapularis or long axis of the long head of the biceps were not analyzed by ultrasonography. However, anteriorly projected spurs, which are suggested to be a risk factor for rotator cuff tears, were observed and measured on sonograms and plain

radiographs.

Ultrasonography is suitable for detecting and diagnosing soft tissue disorders, including rotator cuff tears [21-23]. Moreover, the ready accessibility and dynamic imaging of ultrasonography render it suitable for diagnosing calcific tendinitis and fractures [24,25]. Calcium deposits appear hyperechoic with or without posterior acoustic shadowing, while fractures appear as an interruption of the smooth cortical surface. Ultrasonography is commonly used to guide injections and more invasive procedures, such as needling and barbotage for treating calcific tendinitis [26,27]. In this study, it was seldom difficult to distinguish between acromial spurs and the coracoacromial ligament. Since ultrasonography provides dynamic images, the study participants were asked to extend or rotate their arm internally or externally. Acromial spurs remained still during movement of the humeral head, different from the coracoacromial ligament, which experienced some movement. This discrepancy helped to differentiate acromial spurs from the coracoacromial ligament. Also, multiplanar images, which ultrasonography provides, helped to identify the shape of the spur and to measure the length.

This study had some limitations. First, there was a degree of measurement bias associated with the picture archiving and communication system, although the mean values of two blinded interpreters were obtained to overcome this. Second, measurement bias also arose from beam projection and magnification errors on the plain radiographs. Third, acromion type—and anatomical variations therein—were not assessed. Fourth, only anteriorly projected spurs were observed on ultrasonography; medial and inferior spurs are difficult to observe using ultrasonography. Fifth, there is a possibility of selection bias as this study was a retrospective investigation and included a relatively small population sample (52 cases). However, all of the ultrasonography examinations were performed by a single surgeon with 10 years of ultrasonography experience and a case volume of 100 cases per month.

Some strengths of this study should also be discussed. First, this is the first study to our knowledge to measure acromial spurs using ultrasonography. This study revealed a correlation between plain radiography and ultrasonography findings. The results suggest that ultrasonography has diagnostic value for confirming rotator cuff disorders having an acromial spur.

Anteriorly projected acromial spurs were well-visualized by ultrasonography. No differences in acromial spur length were detected between on plain radiographs (supraspinatus outlet view and 30° caudal-tilt view) and sonograms. The correlation coefficients between the plain radiographs and ultrasonography measurements exceeded 0.7.

## ORCID

Hyungsuk Kim <https://orcid.org/0000-0003-3400-0263>  
 Syungkyun Choi <https://orcid.org/0000-0001-6270-4896>  
 Soo Bin Park <https://orcid.org/0000-0002-6555-5803>  
 Hyun Seok Song <https://orcid.org/0000-0002-7844-2293>

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## Original Article

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# Calcific tendinitis of the shoulder in the Korean population: demographics and its relation with coexisting rotator cuff tear

Yon-Sik Yoo<sup>1</sup>, Jin-Young Park<sup>2</sup>, Myung-sun Kim<sup>3</sup>, Nam-Su Cho<sup>4</sup>, Yong-Beom Lee<sup>5</sup>, Seung-Hyun Cho<sup>6</sup>,  
Kyoung Jin Park<sup>7</sup>, Chul-Hyun Cho<sup>8</sup>, Bong Gun Lee<sup>9</sup>, Dong Joo Shin<sup>10</sup>, Han-Hoon Kim<sup>11</sup>, Tae Kang Lim<sup>11</sup>

<sup>1</sup>Department of Orthopedic Surgery, Hallym University Dongtan Sacred Heart Hospital, Hwaseong, Korea

<sup>2</sup>Global Center for Shoulder, Elbow and Sports at Neon Orthopaedic Clinic, Seoul, Korea

<sup>3</sup>Department of Orthopaedics, Chonnam National University College of Medicine, Gwangju, Korea

<sup>4</sup>Department of Orthopedic Surgery, Kyung Hee University Hospital at Gangdong, Seoul, Korea

<sup>5</sup>Department of Orthopaedic Surgery, Hallym University Sacred Heart Hospital, Anyang, Korea

<sup>6</sup>Seoul Metropolitan Seonam Hospital, Seoul, Korea

<sup>7</sup>Goodsam Orthopaedic Clinic, Cheongju, Korea

<sup>8</sup>Department of Orthopedic Surgery, Keimyung University Dongsan Medical Center, Keimyung University School of Medicine, Daegu, Korea

<sup>9</sup>Department of Orthopaedics, Hanyang University College of Medicine, Seoul, Korea

<sup>10</sup>Department of Orthopaedics, Daegu Fatima Hospital, Daegu, Korea

<sup>11</sup>Department of Orthopedic Surgery, Nowon Eulji Medical Center, Eulji University School of Medicine, Seoul, Korea

**Background:** To evaluate the demographics, clinical and radiographic features of calcific tendinitis of the shoulder in the Korean population, specifically focusing on the incidence of coexisting rotator cuff tear.

**Methods:** Between October 2014 and January 2015, we performed a prospective multicenter study with 506 patients from 11 training hospitals in Korea. We collected data of demographics and radiographic analysis based on simple radiographs, clinical assessments based on visual analog scale (VAS) and the American Shoulder Elbow Surgeons (ASES) score, and treatment modalities that are used currently. We also evaluated coexisting rotator cuff tear by ultrasonography (US) or magnetic resonance imaging (MRI) images.

**Results:** There were 402 female patients (79%) with mean age of 55 years (range, 31–87 years). Mean duration of symptoms was 16 months. Mean size of calcific materials was 11.4 mm (range, 0–35 mm). Mean value of VAS and ASES scores were 6.5 (range, 1–10) and 47 (range, 8–95), respectively. Of 383 patients (76%), 59 (15%) had rotator cuff tear including 15 full-thickness tears on US or MRI. Patients with rotator cuff tears were significantly associated with older age, recurrent symptoms, menstrual disorders in females, and having undergone calcification removal surgery and rotator cuff repair (all  $p < 0.05$ ).

**Conclusions:** This study reported demographic, radiographic, and clinical features of calcific tendinitis of the shoulder in Korean population, which were not different from those of Western population. Coexisting rotator cuff tear was found with 15% incidence in this large series, suggesting that further radiographic study to evaluate rotator cuff tear might be needed in some calcific tendinitis patients of older age and presenting with recurrent symptoms.

**Keywords:** Calcific tendinitis; Epidemiology; Rotator cuff

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Correspondence to: Tae Kang Lim

Department of Orthopedic Surgery, Nowon Eulji Medical Center, Eulji University School of Medicine, 68 Hangeulbiseong-ro, Nowon-gu, Seoul 01830, Korea

Tel: +82-2-970-8036, Fax: +82-2-973-3024, E-mail: [shouldertk@gmail.com](mailto:shouldertk@gmail.com), ORCID: <https://orcid.org/0000-0001-8752-3987>

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## INTRODUCTION

Calcific tendinitis is one of the common causes of shoulder pain and discomfort, and an incidence rate of 2.7%–20% has been reported [1]. Several hypotheses have been raised as to the cause of calcific tendinitis, including active cell-mediated process, rotator cuff tendon degeneration, overuse and microinjury, genetic predisposition, local metabolic or hemodynamic abnormalities, and subacromial impingements, but the exact pathophysiology remains unclear [2]. The calcific tendinitis of the shoulder is prevalent in the dominant and more frequently used arm [1]. It is highly correlated to old age, diabetes, or smoking and frequently occurs in patients who raise their arms overhead [2].

Demographic factors can be related to the pathogenesis of disease and also affect its prognosis. In calcific tendinitis, it has been reported that being female, bilateral morbidity, and having multiple calcific deposits are associated with poor prognosis in long-term clinical results [3]. Contrary to the existing belief that the treatment of calcific tendinitis is benign and self-limited, de Witte et al. [3] recently reported that pain and discomfort of the shoulder still persisted in more than 50% of patients even after 14 years of follow-up. Considering these outcomes, studies of demographic and radiographic features to determine treatment options and assess prognosis at the initial diagnosis of calcific tendinitis are clinically highly significant.

Most of the existing studies [4] on demographic factors, radiographic characteristics, long-term course, and prognostic factors of the disease are limited by small numbers of patients. Studies involving larger numbers of patients are needed. Besides, studies [3,5] that included relatively large numbers of research subjects were all conducted outside the country. No studies have been reported investigating demographic factors and characteristics associated with calcific tendinitis of the shoulder in the Korean population.

One of the controversies related to calcific tendinitis of the shoulder is whether it is related to the rotator cuff tear. Since calcific tendinitis can be easily diagnosed with only a simple radiographic examination, it is common to first perform conservative treatment without first performing expensive imaging tests such as magnetic resonance imaging (MRI) [5]. In patients who do not respond to conservative treatment, however, a common clinical occurrence is that accompanying rotator cuff tear is diagnosed when additional imaging tests are performed. These clinical experiences occur in patients with calcific tendinitis of the shoulder diagnosed by simple radiographic examination. The question remains as to whether there is a need to diagnose early the presence of rotator cuff tear. Indeed, according to a study by

Jim et al. [4], rotator cuff rupture was reported in 22 of 81 patients with calcified tendinitis. However, this study is limited in the number of patients, and because it is a study performed through simple radiographs of arthrography after administration of a contrast agent, diagnostic accuracy is limited. In addition to this study, the presence of rotator cuff tear in calcified tendinitis of the shoulder has been reported rarely.

Therefore, the purpose of this study was to investigate the demographic, clinical, and radiological factors of calcific tendinitis of the shoulder joint in a large number of Koreans and to investigate the prevalence of rotator cuff tear associated with calcific tendinitis.

## METHODS

This study was approved by the Institutional Review Board of Nowon Eulji Medical Center (IRB No. EMCIRB 19-126), and informed consent was waived due to retrospective nature of this study.

### Materials

From November 2014 to January 2015, a retrospective study was conducted on 506 patients diagnosed with calcific tendinitis of the shoulder at 11 major training hospitals nationwide. In this study, the inclusion criteria were patients that visited the hospital for shoulder pain and a simple radiographic examination with observed calcium deposits around the shoulder. Patients with infections or previous fracture or surgery in the same area of the shoulder joint were excluded from the study.

### Demographic and Clinical Evaluation

Demographic characteristics of patient age, sex, dominant arm, bilateral arm, trauma history, occupation, regular exercise, hobbies using shoulders, and smoking were investigated. Occupations were categorized into housework, labor, office work, and others. Labor and office work were classified according to whether arms were used in vocational activities. Regular exercise was defined as occurring at least twice a week (ex. swimming or jogging, etc.). Smoking was defined as only current smokers. Diabetes, thyroid disorder, and rheumatoid arthritis were investigated as comorbid diseases, and the history of menopause and obstetrics and gynecological disease was investigated in females. Diseases that affect estrogen metabolism such as endometriosis, ovarian cysts, polycystic ovary syndrome, and infertility treatment history were investigated. At the first visit, the duration of symptoms, the presence of nocturnal pain, visual analog scale (VAS), and American Shoulder Elbow Surgeons (ASES) scores

were measured for clinical evaluation. The investigation classified treatments into nonsurgical such as extracorporeal shock wave treatment or surgical.

### Radiological Evaluation

The location of calcium was evaluated in the standard radiographs of anteroposterior, axial and supraspinatus outlet views. Calcium located in the anterior of the scapular spine and over the greater tuberosity was particularly noted as calcium deposit in the supraspinatus tendon. Deposits in the posterior of the scapular spine and the greater tuberosity were considered as in the infraspinatus tendon. Calcium originating from the subscapularis was determined as the case in front of the lesser tuberosity in the outlet and axial view. The size of calcium deposit was measured on picture archiving and communicating system (PACS) and its characteristic was classified by Gartner method [6] (Fig. 1). Furthermore, ultrasound or MRI was performed to investigate the presence or absence of accompanying rotator cuff tear.

### Statistical Analysis

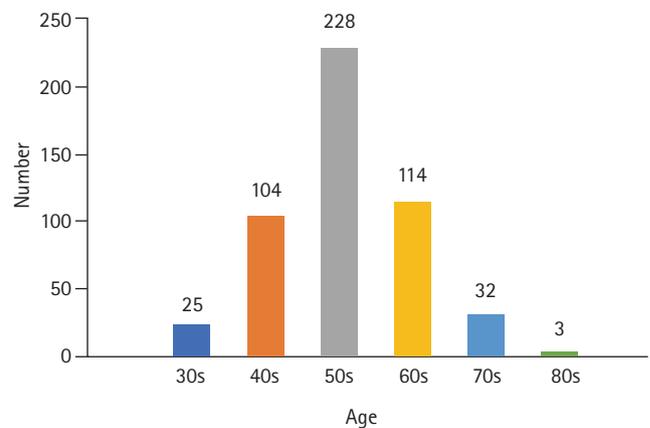
Based on these results, the relationship between demographic variables such as age, sex, presence of comorbid diseases, clinical symptoms, radiographic findings, and surgical treatment was statistically analyzed. The clinical relationship between symptoms and surgery was statistically analyzed, particularly the relation between rotator cuff tear and demographic factors. A chi-square test was performed for nominal variable analysis, and an independent t-test was performed for continuous variable analysis. Cases where the p-value was less than 0.05 were judged to have statistical significance.

## RESULTS

### Demographic Factor

Of the total 506 patients, there were 402 females (79%) and 104 males (21%). Of the total 506 patients, there were 402 females (79%) and 104 males (21%) and the average age was 55 years (range, 31–87 years). By age group, the 50s had the highest incidence at 45%, followed by 23% in 60s, 21% in 40s, 6% in 70s, and 5% in 30s (Fig. 2). Among the total patients, 404 (79%) were confirmed as being affected in the dominant arm, and 98 (19%) cases were bilaterally affected at the time of diagnosis. There were 64 patients (12.6%) who had a history of trauma before the onset of symptoms.

As for the occupation, unemployed, including housekeeping, was the most common, with 187 (37%), followed by laborers with 108 (21%), office workers with 94 (19%), and others with 87 (17%). One hundred and six patients (21%) answered that they



**Fig. 2.** Distribution of calcific tendinitis by age group. The 50s had the highest incidence at 45%, 60s were 23%, 40s at 21%, 70s at 6%, and 30s at 5% by age group.



**Fig. 1.** Gartner classification of calcific tendinitis. (A) Gartner type 1 has a clear, uniform, and dense shape. (B) Gartner type 2 has a clear boundary but is uneven inside or a uniform inside but an uneven boundary. (C) Gartner type 3, with no borders, transparent or cloud-like.

were exercising regularly, and 77 (15%) were exercising using their shoulders. The current smokers included 42 (8%). As for systemic and medical diseases, diabetes was present in 62 (12%), thyroid disease in 32 (6%), and rheumatic disease in 13 (3%). Among 377 female patients, 179 (47%) had achieved menopause, and 39 (10%) had a history of obstetric diseases (Table 1).

**Table 1.** Demographics and clinical outcomes

Variable	Value
Age (yr)	55 (31–87)
Female sex	402 (79)
Dominant side	404 (79)
Bilateral	98 (19)
Symptom duration (mo)	16 (0–180)
Recurrent symptom	102 (20)
Trauma history	64 (13)
Night pain	358 (71)
Occupation	
Housework	187 (39)
Manual labor	108 (21)
Office work	94 (19)
Other	87 (17)
Regular exercise	106 (21)
Exercise using shoulder	77 (15)
Smoking	42 (8)
Diabetes	62 (12)
Thyroid disease	32 (6)
Rheumatoid disease	13 (3)
Menopause	179 (47)
Obstetric disease	39 (10)
Body mass index (kg/m <sup>2</sup> )	23.6 (16.42–41.67)
Size of calcification (mm)	11.4 (0–35)
Gartner classification	
Type I	171 (34)
Type II	177 (35)
Type III	120 (24)
Coexisting rotator cuff tear	59 (15)
Visual analog scale score	6.5 (1–10)
American Shoulder Elbow Surgeons score	47 (8–95)
Operation	30 (6)

Values are presented as mean (range) or number (%).

**Table 2.** Clinical characteristics by sex

Variable	Male (n = 104)	Female (n = 401)	p-value
Age (yr)	56.7 ± 10.4	55.1 ± 8.9	0.124
Recurrent symptom	22 (21)	102 (25)	0.443
Night pain	63 (61)	295 (73)	0.015
Trauma history	13 (13)	50 (13)	0.993
Visual analogue scale score	6.2 ± 1.9	6.6 ± 2.0	0.067
Size of calcification (mm)	11.4 ± 7.2	11.4 ± 6.1	0.972

Values are presented as mean ± standard deviation or number (%).

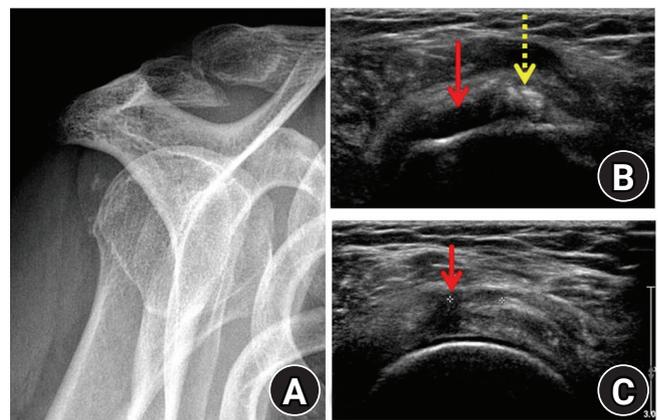
When comparing clinical characteristics according to gender, the frequency of night pain in females was statistically significantly higher (73% for women and 61% for men,  $p = 0.015$ ). Other demographic and clinical characteristic differences between men and women were not observed (Table 2).

### Clinical Features

The average symptom duration was 16 months (range, 1–180 months), the average pain score (VAS) at the time of visit was 6.6 (range, 1–10), and the ASES score was 47 (range, 8–95). Previously, 102 (20%) were diagnosed with calcific tendinitis and had recurrence of symptoms after a symptom-free period. Sleep disturbance due to night pain was observed in 358 (70.7%). The most common treatment for patients was the use of oral analgesics (93%), steroid injection therapy (53%), physical therapy (42%), extracorporeal shock wave therapy (16%), and surgical arthroscopic calcium removal and rotator cuff repair (6%).

### Radiological Results

The average size of calcium deposit was 11.6 mm (range, 0.9–35 mm) on simple radiographic examination. The location of occurrence was supraspinatus: 322 cases (64%), Infraspinatus 125 cases (25%), subscapularis 79 cases (16%), and Teres Minor 5 cases (1%). According to Gartner classification [6], there were 171 cases of type 1 (34%), 177 cases of type 2 (35%), and 120 cases of type 3 (24%). Ultrasound or MRI was performed in 383 out of 506 cases (76%), of which 59 (15%) were diagnosed with rotator cuff tear. Partial-thickness tear was more common with 44 cases (11%), but patients with full-thickness tear (Fig. 3) were also observed in 15 cases (4%). (Fig. 4)

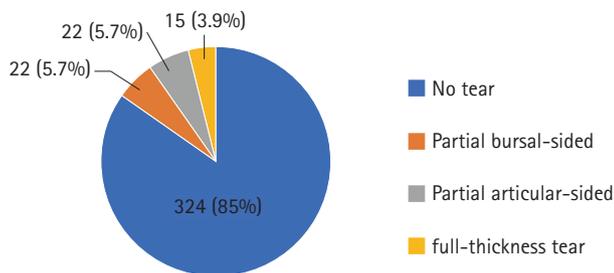


**Fig. 3.** A 59-year-old female patient with calcific tendinitis with rotator cuff tear. (A) Radiation examination of the shoulder joint exhibited calcium in the inferior tendon. (B, C) Ultrasound examination showed rotator cuff tear (solid arrows) and calcium deposition at the same time (dotted arrow).

When comparing calcific tendinitis patients with rotator cuff tear against those without rotator cuff tear on ultrasound or MRI, the average age of patients with rotator cuff tear was 58 years, significantly higher than the 55 year average age of patients without ( $p=0.025$ ). In addition, the associated frequency of rotator cuff tear in patients with recurring symptoms (41%) was significantly higher ( $p=0.012$ ) than in the other group (23%). The frequency (83%) was significantly higher than that of the other group (68%) ( $p=0.042$ ). In patients who had menopause, the associated frequency of rotator cuff tears (50%) was significantly higher than in the group without menopause (35%,  $p=0.014$ ). The associated frequency of rotator cuff tear in the surgical group (33%) was also significantly higher than in the nonoperative group (10%,  $p<0.001$ ) (Table 3).

## DISCUSSION

This study is a multicenter epidemiologic investigation of the demographics, imaging, and clinical features of calcific tendinitis in



**Fig. 4.** Rotator cuff tear associated with calcific tendinitis. Rotator cuff tear accompanied in 15% of cases: partial rupture of the mucous sac was present in 5.7%, partial rupture of the joint in 5.7%, and 3.9% showed full rupture.

Koreans. The most important finding was that 15% of patients with calcific tendinitis had a rotator cuff tear. The average symptom age of calcific tendinitis was 55 years, and it tended to be more prevalent in females. About 71% of patients had a high rate of night pain. Among treatment modalities, oral analgesics (93%) were the most common, followed by steroid injection therapy (53%).

According to Harvie et al.'s study [7] on the relationship between the natural course of calcific tendinitis and endocrine diseases, the prevalence of endocrine diseases such as hypothyroidism was high in patients with calcific tendinitis. The proportion of female patients with calcific tendinitis was high, suggesting that estrogen might play a role in the pathogenesis. In this study's results, the prevalence of females was at 79%, diabetes was confirmed in 12% of patients, and thyroid disease was also confirmed in 6% of patients. Among female patients with calcific tendinitis, previous studies reported that menstrual irregularities and hysterectomy rates were higher than those of the general population [7] and that finding corresponded to a high proportion of menstrual irregularities (47%) and obstetric diseases (10%) found in this study.

According to the results of a long-term follow-up study by de Witte et al. [3], long-term prognosis was poor when calcific tendinitis invaded the dominant arm or bilateral arms. It is more common for calcific tendinitis to invade the dominant arm [1] because the rotator cuff contracts during the lifting motion, making it hemodynamically susceptible to local ischemia [2]. In this study, it was confirmed that the dominant arm invading patients accounted for a large proportion (79%) of cases, and it was more frequent in houseworkers and laborers than in office workers. As such, a patient's dominant arm activities in occupation and hobbies is related to the cause of the disease and the prognosis, and

**Table 3.** Clinical characteristics comparing groups with and without coexisting rotator cuff tear

Variable	No rotator cuff tear (n = 324)	Coexisting rotator cuff tear (n = 59)	p-value
Age (yr)	55.2 ± 8.9	58.0 ± 8.6	0.025
Female sex	241 (74)	42 (71)	0.157
Recurrent symptom	76 (23)	24 (41)	0.012
Night pain	250 (68)	48 (83)	0.042
Trauma history	48 (15)	10 (17)	0.297
Diabetes	30 (9)	2 (6)	0.748
Thyroid diseases	26 (8)	4 (7)	0.556
Menopause	113 (35)	29 (50)	0.014
Obstetric disease	30 (9)	7 (12)	0.087
Rheumatoid disease	12 (4)	2 (3)	0.66
Size of calcification (mm)	11.1 ± 6.0	12.3 ± 7.2	0.332
Operation	31 (10)	19 (32)	<0.001

Values are presented as mean ± standard deviation or number (%).

so it must be carefully checked before treatment.

According to previous studies, the radiological size and Gartner classification of calcium cannot accurately predict patients' prognosis. Still, radiographic improvement (reduction in size or improvement of Gartner classification) over time was associated with good clinical outcomes [3]. As a complication of calcific tendinitis, the rotator cuff tear can occur before or during surgery. Of these, 23% of patients reported that rotator cuff tear was also present. Hsu et al. [8] also reported that calcific tendinitis and rotator cuff tear occurred together in 28% of patients on shoulder angiography and that calcium deposits were rather small in patients with rotator cuff tear. Gotoh et al. [9] reported that calcific tendinitis could progress and become a rotator cuff tear. The rotator cuff tear repeats inflammation and regeneration, and calcium deposits reveal a small amount of calcium on the radiograph [10]. In this study, concomitant rotator cuff tear was confirmed in 15% of patients who underwent ultrasound or MRI examination. The patient group with rotator cuff tear was older and had more recurrence of symptoms and menstrual irregularities than the group without the rotator cuff tear. Rotator cuff tear was also significantly more likely in women. The rotator cuff tear was associated with a high frequency of 32% of the group that underwent surgery perhaps due to the more active surgical treatment. In the case of calcific tendinitis, conservative treatment is generally performed first. The prognosis is generally good, but worsens in patients with persistent symptoms, with recurring symptoms, old age, or patients with menstrual irregularities [11]. In some cases, rotator cuff tear can coexist with calcific tendinitis of the shoulder. Therefore, an active imaging test should be performed, and treatment should be performed with the accompanying rotator cuff tear in mind.

This study has several limitations. First, the frequency of calcific tendinitis occurrence relative to the population was unknown. There was no control group, so the risk factors for inducing calcific tendinitis were unknown. Second, as a multicenter study, several different observers measured calcium deposit size in a simple imaging test. There is a possibility that a difference in reliability among testers may occur. In addition, the diagnosis of rotator cuff tear on MRI cannot exclude the reliability factor among examiners. Ultrasound in particular was performed by several examiners leading to a limitation in that the examination was not necessarily consistent. The accuracy may be different for each institution. Third, whether the rotator cuff was ruptured due to degenerative changes or a burst of calcium, it was impossible to clarify the pathophysiology, i.e., whether calcium was produced due to inflammation or regeneration.

This study reported demographic, radiographic and clinical

features of calcific tendinitis of the shoulder in the Korean population, which were not different from those of Western populations. Coexisting rotator cuff tear was found with 15% incidence in this large series, suggesting that further radiographic study to evaluate rotator cuff tear might be needed in some calcific tendinitis patients of older age and with recurrent symptoms.

## ORCID

Tae Kang Lim

<https://orcid.org/0000-0001-8752-3987>

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## Case Report

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# A humeral hemiarthroplasty with biologic resurfacing of the glenoid using an allo-Achilles tendon: two case reports

Ki-Yong Choi<sup>1</sup>, Kyu-Hak Jung<sup>2</sup>, Young-Kyu Kim<sup>2</sup>, Young-Hyun Yoon<sup>2</sup>

<sup>1</sup>Department of Orthopedic Surgery, Kangwon National University Hospital, Chuncheon, Korea

<sup>2</sup>Department of Orthopedic Surgery, Gil Medical Center, Gachon University College of Medicine, Incheon, Korea

A hemiarthroplasty with biologic resurfacing of the glenoid is one procedure that can be performed in young patients where total shoulder arthroplasty may be difficult. The authors introduced two cases in which this procedure was performed. This approach is one treatment option for young glenoid humeral arthritis patients that addresses some of the shortcomings of an isolated hemiarthroplasty.

**Keywords:** Biologic; Resurfacing; Hemiarthroplasty

For elderly patients with end-stage glenohumeral arthritis, total shoulder arthroplasty (TSA) is the gold standard treatment option. Several treatment options exist in young patients, such as arthroscopic debridement, hemiarthroplasty with or without glenoid treatment, and TSA [1]. However, there is a high probability that a TSA will require revision surgery at some point in its lifetime, especially in young and active patients. Denard et al. [2] reported the 10-year survival rate of TSA was only 62.5% in patients aged 55 years or younger at the time of surgery. Many authors have reported that patients younger than 50 years tend to have worse clinical outcomes with TSA [3]. One other treatment option is to perform an isolated humeral hemiarthroplasty. However, it was reported that the hemiarthroplasty procedure is inferior to TSA because the former produces more pain, leads to less range of motion (ROM), and generally has a poor functional outcome [4]. Accordingly, the authors considered a technique to delay the TSA and to compensate for the shortcomings of hemiarthroplasty by performing a hemiarthroplasty with biologic resurfacing of the glenoid in two patients. One case involved severe joint destruction due to rheumatoid arthritis, and the other case presented with osteoarthritis due to infection sequelae. This report details both patients' clinical and radiologic outcomes.

arthroplasty by performing a hemiarthroplasty with biologic resurfacing of the glenoid in two patients. One case involved severe joint destruction due to rheumatoid arthritis, and the other case presented with osteoarthritis due to infection sequelae. This report details both patients' clinical and radiologic outcomes.

## CASE REPORT

This study was approved by the Institutional Review Board of Gil Medical Center, Gachon University (IRB No. GAIRB2020-405). Owing to the retrospective design, the requirement for informed consent was waived.

### Case 1

A 50-year-old female patient complained of pain in the left shoulder joint and difficulty with active forward elevation (aFE) for the last 4 years that had worsened about 1 year ago. The pa-

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Correspondence to: Kyu-Hak Jung

Department of Orthopedic Surgery, Gil Medical Center, Gachon University College of Medicine 21 Namdong-daero 774beon-gil, Namdong-gu, Incheon 21565, Korea

Tel: +82-32-460-3384, Fax: +82-32-460-3383, E-mail: [jjangumom52@gmail.com](mailto:jjangumom52@gmail.com), ORCID: <https://orcid.org/0000-0003-0211-8005>

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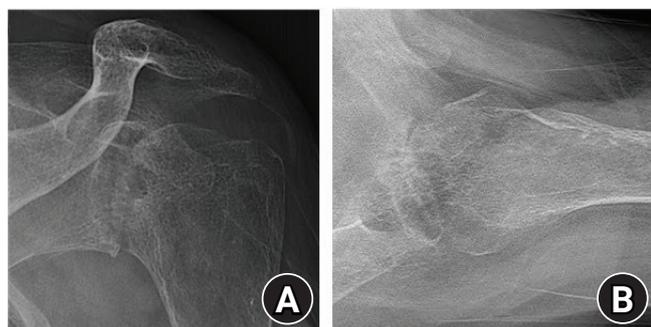
Conflict of interest: None.

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tient had been diagnosed with rheumatoid arthritis 10 years ago and had been prescribed medications, such as methotrexate and corticosteroids. The patient did not show symptom improvement despite conservative treatments, such as steroid injections, non-steroidal anti-inflammatory drugs, and analgesics at other clinics for more than 1 year.

Upon physical examination, the aFE of the left shoulder joint was 30°; active external rotation at the side (aERs) was 20°, and active internal rotation to the posterior (aIRp) was at buttock level. Plain radiography revealed a stage 2 level of rheumatoid arthritis of the shoulder joint and also humeral head destruction according to Levigne and Franceshi's classification (Fig. 1) [5]. Magnetic resonance imaging (MRI) showed a partial tear of grade 2 of the subscapularis and supraspinatus tendon, according to Ellman's classification and 32% supraspinatus muscle atrophy (Fig. 2) [6]. Hemiarthroplasty with biologic resurfacing of the glenoid was performed due to the patient's young age, and the integrity of the cuff was maintained despite the partial tear. The visual analog scale (VAS) pain score had significantly improved from 10 to 1 at 6 weeks postoperatively. Six months after surgery, the aFE was 145°, the aERs was 60°, and the aIRp was at the T12 level, which was no different than the patient's right shoulder joint. The same ROM was maintained at 4 years postoperatively.



**Fig. 1.** The preoperative radiographs of case 1. (A) The anterior-posterior view. (B) The axial view.

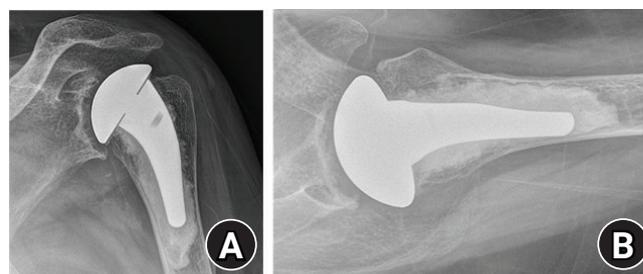


**Fig. 2.** Preoperative magnetic resonance images of case 1. (A) The oblique-coronal view. (B) The axial view. (C) The oblique-sagittal view.

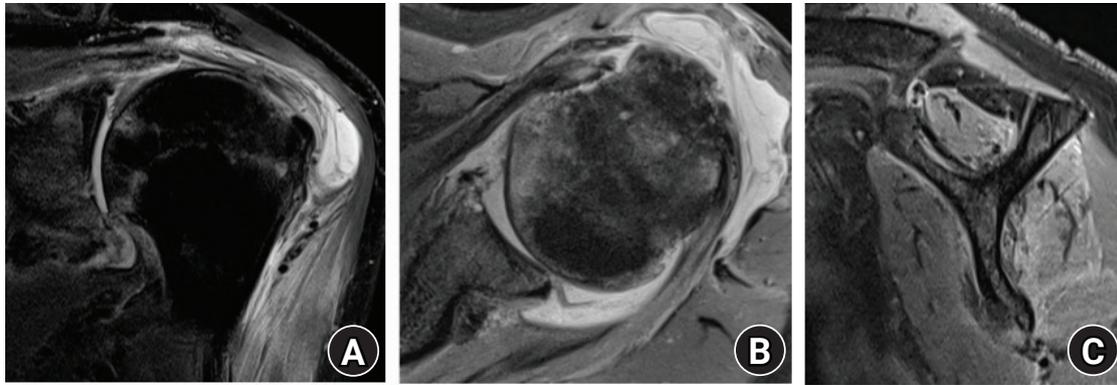
At the final follow-up visit, the pain was rated as a VAS score of 0. A joint space of 3 mm or greater was maintained even on the final plain radiographs, and complications such as stem loosening and infection were not observed (Fig. 3).

**Case 2**

A 52-year-old male patient complained of severe pain in both shoulders and visited the emergency department with a fever of 39°C. The patient had undergone an open rotator cuff repair of the left shoulder 3 years previously and until recently had received several steroid injections at other hospitals due to multiple joint pain. ROM on both shoulders could not be confirmed due to pain, and local heat and swelling were observed. Laboratory blood testing revealed a prominent acute infection based on an elevated C-reactive protein (CRP) of 28.68 mg/dL (normal range, 0–0.5 mg/dL) and a procalcitonin of 8.06 ng/mL (normal range, 0–0.04 ng/mL). Enhanced MRI revealed acute pyogenic arthritis in both shoulders, and arthroscopic debridement was performed on both shoulders. Afterwards, the infection status of the right shoulder improved, but the left shoulder still showed severe pain and signs of infection. Two months later, additional enhanced MRI images showed progression of osteomyelitis of the humeral head of the left shoulder (Fig. 4). Open debridement, a resection of the humeral head, and prosthesis with antibiotic-loaded acryl-



**Fig. 3.** The radiographs of case 1 more than 4 years postoperatively. (A) The anterior-posterior view. (B) The axial view.



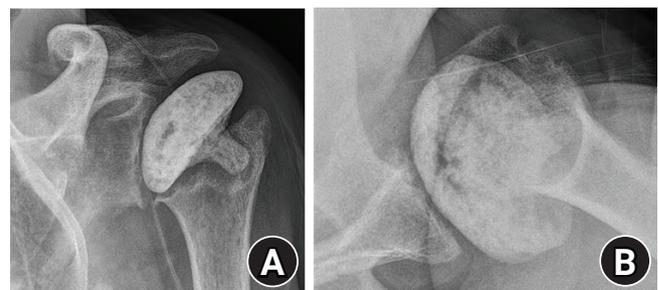
**Fig. 4.** Preoperative magnetic resonance images of case 2. (A) The oblique-coronal view. (B) The axial view. (C) The oblique-sagittal view.

ic cement (PROSTALAC) insertion were performed. Afterwards, the signs of infection in the left shoulder improved, but joint destruction of the left shoulder gradually progressed on plain radiography, and the patient's pain worsened. Six months after PROSTALAC insertion, hemiarthroplasty with biologic resurfacing of the glenoid was planned because the patient was highly active and young (Fig. 5). At the time of surgery, no infection ( $\leq 5$  polymorphic neutrophils per high-power field) was found on the frozen section near the glenoid and humerus, and the operation proceeded as planned. After surgery, the patient's left shoulder pain improved from a VAS of 10 preoperatively to a VAS of 3 postoperatively. Three months preoperatively, the aFE was  $130^\circ$ , the aERs was at  $60^\circ$ , and the aIRp was at the L2 level. However, the pain increased 6 months after surgery; at the final follow-up visit 2 years postoperatively, the VAS was 6, aFE was  $90^\circ$ , aER was  $40^\circ$ , and aIRp was at the L4 level. There were no prominent infection signs, such as fever, swelling, redness, and local heat, but the CRP continued to be maintained at 1–2 mg/dL (normal range, 0–0.5 mg/dL). In addition, stem loosening or bony erosion was not noted, and a joint space of 3 mm or greater was maintained (Fig. 6).

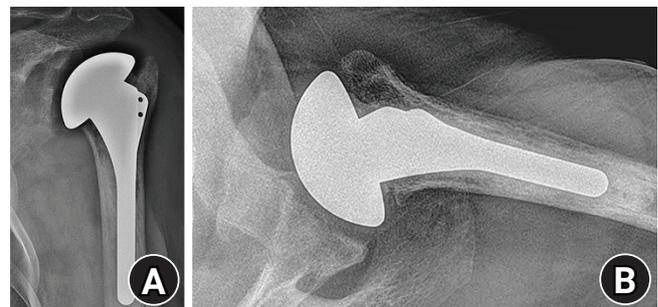
### Surgical Procedures and Rehabilitation

Patients underwent the procedure in the  $30^\circ$  beach chair position under general anesthesia. A delto-pectoral approach was used in all cases. The subscapularis was detached from the lesser tuberosity. No lesser tuberosity osteotomies were performed. The humeral head was cut with an oscillating saw along the anatomic neck. Before the operation, the diameter of the humeral head was calibrated on plain radiographs, and the size of the humeral head of the implant was confirmed using the resected head of the humerus in the operative field.

During the glenoid procedure, the soft tissue and capsule around the glenoid were carefully released to preserve the la-



**Fig. 5.** The preoperative radiographs of case 2. (A) The anterior-posterior view. (B) The axial view.



**Fig. 6.** The radiographs of case 2 2 years postoperatively. (A) The anterior-posterior view. (B) The axial view.

brum, and the glenoid was finally exposed. Curettage of the cartilage of the glenoid and multiple drilling procedures were performed. Four double-loaded absorbable suture anchors with nonabsorbable sutures were inserted into four edges of the glenoid surface (at the 12, 3, 6, and 9 o'clock positions) (Fig. 7A). Next, the allo-Achilles tendon graft was prepared. The 15-cm  $\times$  3-cm raw tendon was folded and made into a final 5-cm  $\times$  3-cm graft, and the edge of the tendon was sutured using the Krackow technique with a non-absorbable suture (Fig. 7B). The final prepared graft was approximately 5–7 mm thick. The graft was passed in a horizontal mattress fashion through all the sutures from the suture anchors (Fig. 7C). After inserting the graft into the glenoid



**Fig. 7.** (A) Preparation of the glenoid and insertion of four double-loaded absorbable anchors with nonabsorbable sutures. (B) The final appearance of the prepared allo-Achilles tendon graft. (C) The graft was passed in a horizontal mattress fashion through all the sutures. (D) The final seating of the graft in the shoulder.

while maintaining even tension, all sutures were tied. The remaining edges of the graft were sutured to the labrum using a simple suture technique with an absorbable suture (Fig. 7D).

Next, hemiarthroplasty of the humeral side was performed. The humeral canal was prepared and trialed to determine the most appropriate size and version. The best humeral component was then implanted, and the subscapularis was attached to the lesser tuberosity using a transosseous suture technique. Routine wound closure was completed, and drains were placed. After the surgery, an abductor brace was applied for 6 weeks. On the first postoperative day, passive pendulum exercises and isometric exercises were performed. Three weeks after the surgery, passive shoulder motion was started with gradual increases in the ROM. Active ROM exercises were performed from the 6th week postoperatively. Strengthening exercises were allowed to begin at 12 weeks postoperatively.

## DISCUSSION

This case report described two cases of hemiarthroplasty with biologic resurfacing using an Achilles tendon allograft. Glenohumeral arthritis in young and active patients remains a challenge. For end-stage glenohumeral arthritis, the best option for surgical treatment is TSA. However, this procedure may be contraindicated in young and active patients due to concerns about the high risk of revision surgery due to glenoid component loosening and polyethylene wear or dissociation. Traditionally, a hemiarthroplasty alone has been the most common surgical procedure performed in this young and active patient group. However, long-term follow-up results have shown progressive glenoid erosion, and arthritis may also occur [3].

A hemiarthroplasty with biologic resurfacing was developed due to the risk of progressive arthritis or erosion at the glenoid. Glenoid biological resurfacing with autogenous grafts (including the anterior shoulder capsule, autogenous fascia lata, and also al-

lografts including the Achilles tendon [7], and the lateral meniscus [8]) have been used as an interpositional material on the glenoid. Burkhead and Hutton [9] reported good results in a group of 14 young and active patients with end-stage glenohumeral arthritis following anterior capsule or fascia lata autograft placement to cover the glenoid. Krishnan et al. [7] carried out biological resurfacing with hemiarthroplasty. In terms of pain relief and functional recovery, they confirmed the durability of this procedure and obtained satisfactory results in 91% cases (31/34) during 2–15 years of follow-up. Their study recommended an Achilles tendon allograft as the preferred resurfacing material. Nicholson et al. [8] used a lateral meniscal allograft for a hemiarthroplasty in 30 shoulders and followed their patients for one to 4 years. Pain, ROM, and American Shoulder and Elbow Surgeons scores all improved. However, there was a 17% complication rate. Some authors feel that this lateral meniscus approach is more suitable for load sharing and load bearing. Strauss et al. [10] reported a high rate of clinical failure using a lateral meniscus allograft or human acellular dermal tissue matrix for biologic glenoid resurfacing. This surgical technique has been used in several ways and with a variety of graft materials. However, the best biological resurfacing tissues and healing potentials have yet to be demonstrated. Some investigators have reported favorable long-term results, although others have found this procedure unreliable.

In the present study, we used an Achilles tendon allograft for biologic resurfacing and achieved satisfactory results in a rheumatoid arthritis patient but an unsatisfactory outcome in the case of infection sequela. The satisfactory outcomes are thought to be due to restoring a concentric glenohumeral articulation while preserving the glenoid bone stock. The latter result was likely caused by adhesion of infected tissues and any remaining uncured chronic, low-grade infection. Nevertheless, the advantage of biological resurfacing with hemiarthroplasty is to provide an instant smooth surface and pain relief in young patients without

the complications of TSA, such as glenoid bone loss and implant loosening. Thus, conversion to a TSA procedure may be relatively uncomplicated.

Biological resurfacing is a good treatment option for end-stage glenohumeral arthritis patients who wish to delay TSA and return to active sports or manual labor. More prospective and longer-term studies are necessary to establish a clear criterion for using hemiarthroplasty with biologic resurfacing for young patients with glenohumeral arthritis. However, in limited cases, this procedure may be one of the best treatment options.

## ORCID

Ki-Yong Choi <https://orcid.org/0000-0001-6091-1891>  
 Kyu-Hak Jung <https://orcid.org/0000-0003-0211-8005>  
 Young-Kyu Kim <https://orcid.org/0000-0001-5672-505X>  
 Young-Hyun Yoon <https://orcid.org/0000-0002-3977-9037>

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## Case Report

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# Angioleiomyoma masquerading as shoulder pain

Surekh Ravi<sup>1</sup>, Lazar J Chandy<sup>1</sup>, Gautam Kumar<sup>1</sup>, Biju Jacob<sup>1</sup>, Ami M Emmanuel<sup>2</sup>

<sup>1</sup>Department of Orthopedics, VPS Lakeshore Hospital, Kochi, India

<sup>2</sup>Department of Pathology, VPS Lakeshore Hospital, Kochi, India

Angioleiomyoma is a benign soft tissue tumor originating from vascular smooth muscle. We report a case of a 20-year-old student who presented with pain in the right shoulder of 4 years duration. Shoulder movements were pain-free throughout the range of motion except resisted external rotation. Magnetic resonance imaging visualized a well-circumscribed lesion over the infraspinatus tendon. The lesion was surgically removed and sent for histopathological analysis. Morphology and immunohistochemistry results were suggestive of angioleiomyoma. The most common location for such a lesion is the lower limb, with less than 1% being reported in the upper arm, of which an angioleiomyoma of the shoulder is extremely rare.

**Keywords:** Leiomyoma; Magnetic resonance imaging; Soft tissue neoplasms

Angioleiomyoma is a benign soft tissue tumor that originates from vascular smooth muscle. These are well-circumscribed tumors usually round or oval in shape, commonly presenting as a painful mass. Microscopically, the lesion consists of numerous fine blood vessels of varying size surrounded by a smooth muscle bundle. The World Health Organization has classified them as benign perivascular tumors [1]. The tumor usually presents in the lower extremities, with less than 1% [2] being described in the upper limb. We report a case of a 20-year-old male who had symptomatic angioleiomyoma in the right shoulder.

## CASE REPORT

This study was approved by the Institutional Review Board of CDSCO India, Lakeshore Ethics Committee (No. ECR/120/LAKESHORE/INST/KER/2013/RR-16). The informed consent was received from the patient for publication.

A 20-year-old male visited our out patient department complaining of pain in the right shoulder of 4-year duration. He was a right-handed individual with no comorbidities. The pain was insidious in onset, gradual in progression, absent upon rest, with no diurnal variation, and aggravated by strenuous exercise such as swimming and weightlifting. The visual analog scale score was 6/10 at presentation. The patient had received one intra-articular injection at another clinic suspecting supraspinatus tendinitis, which offered transient pain relief for 1 month.

The clinical examination revealed no deformity, visible swelling, or wasting of muscles. The patient had full pain-free range of movement. The pain was elicited upon resisted external rotation. The laboratory investigations, including total leukocyte count and erythrocyte sedimentation rate, were within normal limits excluding the infective pathology. The plain radiograph of the shoulder was within normal limits. A Siemens Magnetom Skyra 3 Tesla (Siemens, Erlangen, Germany) magnetic resonance imag-

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Correspondence to: Lazar J Chandy

Department of Orthopedics, VPS Lakeshore Hospital, Kochi, Kerala 682040, India

Tel: +91-9447391770, E-mail: [lazarjchandy@gmail.com](mailto:lazarjchandy@gmail.com), ORCID: <https://orcid.org/0000-0003-4521-550X>

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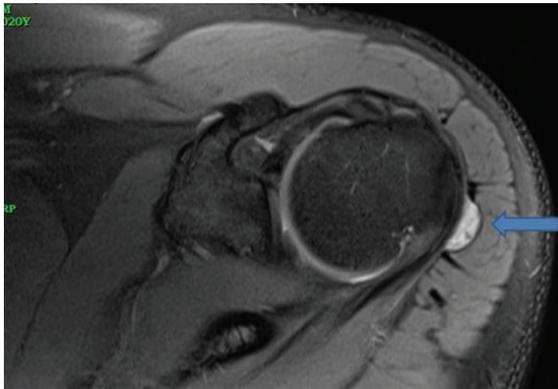
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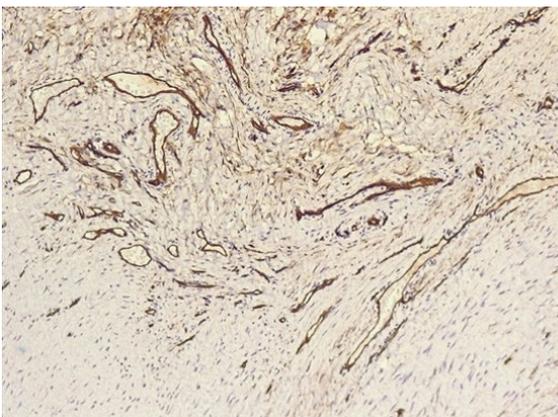
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ing (MRI) instrument was used to visualize a  $1.3 \times 1.2 \times 1.4$  cm, well-circumscribed lesion that was isointense in T1-weighted (T1W) and hyperintense on T2-weighted (T2W) images, along the posterior superficial surface of the infraspinatus tendon (Figs. 1 and 2) near its attachment.

The provisional diagnosis of giant cell tumor (GCT) of the tendon sheath was based on the peritendinous location and T2 hyper-intensity on contrast-enhanced imaging. A ganglion cyst was also considered as a provisional diagnosis due to the well-circumscribed margins and T2 hyper-intensity of the lesion. Ultrasound-guided fine needle aspiration was planned but omitted in view of the high risk of field contamination in suspected malignancy. Open excision biopsy was preferred over arthroscopic biopsy as we considered a differential diagnosis of GCT and possibility of malignant tumor. To avoid tissue contamination and



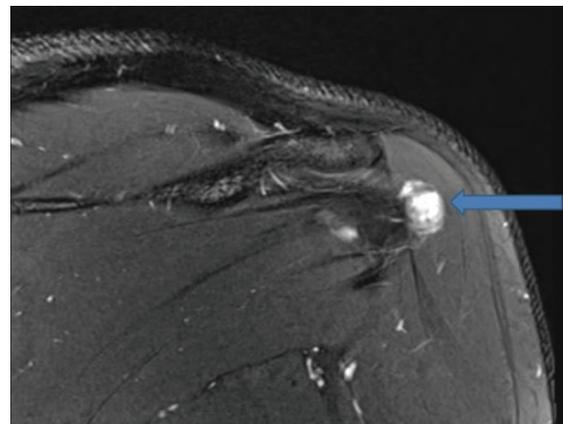
**Fig. 1.** An axial proton density fat saturated image showing a well-demarcated hyperintense lesion along the posterior surface of the infraspinatus tendon protruding into the subacromial subdeltoid bursa. The single arrow in axial proton density fat saturated image showing well demarcated hyperintense lesion along the posterior surface of infraspinatus tendon protruding into the subacromial subdeltoid bursa.



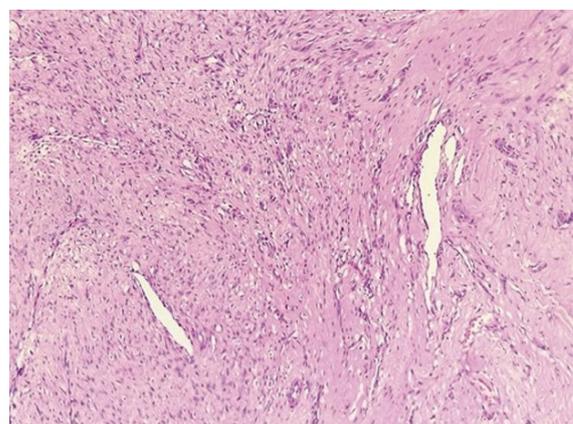
**Fig. 2.** A coronal T2 fat suppressed image showing a well-circumscribed hyperintense lesion along the superficial surface of the infraspinatus tendon protruding into the subacromial subdeltoid bursa.

complete removal, we performed open marginal excision of the lesion.

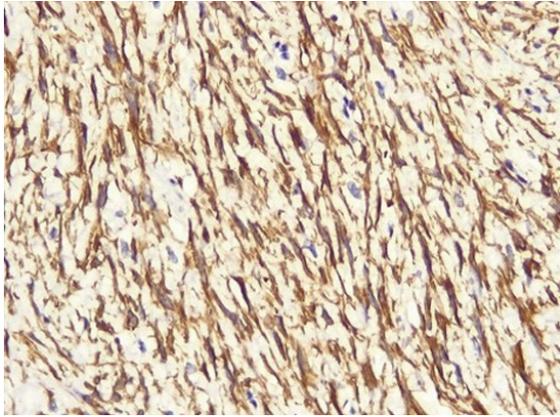
The patient was placed in the beach chair position under general anesthesia, and the lesion was visualized using a posterior approach through a horizontal incision after retracting the deltoid fibers. A well-encapsulated lobulated mass was found lying over the infraspinatus muscle in close proximity but not adherent to the axillary nerve. The mass was removed intact along with part of the subacromial bursa, and the tissue was sent for histopathological evaluation. On gross examination (Fig. 3), a circumscribed firm nodule was observed with adjacent skeletal muscles. The microscopic examination was suggestive of a well-circumscribed neoplasm that was mainly composed of spindly cells; devoid of significant atypia or mitotic activity. The delicate and branching vessels (Fig. 4) were observed within the lesion. On immunohistochemistry (IHC) examination, the spindly cells were positive for vimentin, smooth muscle actin (SMA) (Fig. 5), and caldesmon. The prominent vasculature within the lesion was



**Fig. 3.** Excised gross specimen showing a globular mass with skeletal muscle attached.



**Fig. 4.** H&E-stained 40x magnification showing bland spindle cells with interspersed vascular channels.



**Fig. 5.** Immunohistochemistry smooth muscle actin (SMA) staining at 400× showing cytoplasmic positivity in the spindly cells.



**Fig. 6.** Image of 400× magnification of immunohistochemistry CD34 showing cytoplasmic and membranous positivity in lining endothelial cells.

highlighted by CD34 (Fig. 6).

The morphology and IHC results were suggestive of angioleiomyoma. The patient was prescribed passive mobilization of shoulder from post-operative day 1. The patient was evaluated at 2 and 6 months post-surgery. Shoulder movements were pain-free throughout the range of motion, including resisted external rotation.

## DISCUSSION

Angioleiomyomas are benign soft tissue tumors first described by Stout [3]. Such tumors originate from vascular smooth muscle (tunica media) [4] and comprise around 5% of all soft tissue tumors, of which tumors involving the upper arm represent < 1% [2]. Angioleiomyomas usually present at 40–60 years of age, in female patients. The lower extremities are involved in more than 2/3 of cases [2]. A benign nodule is < 2 cm in size [5] with pain

as the presenting symptom in around 50% of cases [5]. These are well-circumscribed encapsulated tumors usually round or oval in shape. Microscopically, the lesion consists of numerous fine blood vessels of varying size surrounded by smooth muscle bundle [6]. The characteristic spindle-shaped cells have elongated cigar-like nuclei and eosinophilic cytoplasm. IHC results of spindle cells will be positive for SMA and vimentin, while endothelial cells in the vessel will stain positive for CD 34. It is postulated that the presence of neural elements is responsible for patient pain [7]. Transient ischemia due to contraction of smooth muscles is another theory postulated for pain source [2].

The differential diagnosis includes GCT of the tendon sheath and ganglionic cyst. Morimoto [8] classified angioleiomyoma into three types: solid, venous, and cavernous based on histopathology. The case discussed above was a solid variant of angioleiomyoma. MRI characteristics of angioleiomyoma have been well described. The lesion appears isointense to skeletal muscle on T1- and hyperintense on T2W images. The hyperintense area in the T2W image corresponds to the smooth muscle component [9] of the lesion. In angioleiomyoma, MRI lacks specificity in the absence of any specific radiological features. Complete excision of angioleiomyoma is the treatment of choice, as it is both diagnostic as well as therapeutic. The diagnosis is confirmed with histopathological analysis of the excision biopsy sample, supported by IHC analysis. Potential complications include recurrence after excision and malignant transformation to angioleiomyosarcoma. Malignant transformation of angioleiomyoma to angioleiomyosarcoma is extremely rare, with only a few cases [10] described.

Angioleiomyoma is a rare benign soft tissue tumor arising from tunica media of blood vessels. The most common location for the lesion is the lower limb, with less than 1% being reported in the upper arm, of which angioleiomyoma of the shoulder is an extremely rare tumor. When dealing with a benign swelling over the shoulder joint, angioleiomyoma should be kept in the list of differential diagnosis. The diagnosis is made by excision biopsy followed by histopathological evaluation.

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## ORCID

Surekh Ravi	<a href="https://orcid.org/0000-0001-9251-978X">https://orcid.org/0000-0001-9251-978X</a>
Lazar J Chandy	<a href="https://orcid.org/0000-0003-4521-550X">https://orcid.org/0000-0003-4521-550X</a>
Gautam Kumar	<a href="https://orcid.org/0000-0001-9307-6159">https://orcid.org/0000-0001-9307-6159</a>
Biju Jacob	<a href="https://orcid.org/0000-0001-8491-4755">https://orcid.org/0000-0001-8491-4755</a>
Ami M Emmanuel	<a href="https://orcid.org/0000-0003-4338-4000">https://orcid.org/0000-0003-4338-4000</a>

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## Case Report

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# Comparing neuromodulation modalities involving the suprascapular nerve in chronic refractory shoulder pain: retrospective case series and literature review

Saugat Dey

Center for Pain and Spine, Dartmouth-Hitchcock Medical Center, Lebanon, NH, USA

Chronic shoulder pain not relieved by either conservative or surgical management is referred to as chronic refractory shoulder pain. This is a retrospective case series where chronic refractory shoulder pain patients were treated either with peripheral nerve stimulation (PNS) or with pulsed radiofrequency (p-RF) therapy to the suprascapular nerve. Both patients receiving PNS reported 100% pain relief for the first month. At the 3- and 6-month follow-ups, one patient continued to experience 100% relief while the other reported 90% relief. One patient undergoing p-RF experienced about 90% pain relief at both 1- and 3-month intervals and 0% relief at the 6-month interval. The other patient with p-RF experienced 33% relief at 1-month and 0% relief thereafter. No patient reported any complications. The results of previous randomized controlled trials evaluating the efficacy of p-RF administered to the suprascapular nerve were mixed, and there is a lack of published studies on PNS effects. Neuromodulation of the suprascapular nerve can be effective for chronic refractory shoulder pain patients. Larger scale randomized controlled trials comparing PNS and p-RF are needed to better understand their respective therapeutic capacity.

**Keywords:** Shoulder pain; Neuromodulation therapy; Suprascapular Nerve; Pulsed radiofrequency treatment; Peripheral nerve stimulation

Shoulder pain is a common musculoskeletal pain problem. Pain in the shoulder region that persists for 6 months or more has been defined as chronic shoulder pain [1]. The commonest etiologies associated with chronic shoulder pain are rotator cuff muscle disorders, and acromioclavicular joint and glenohumeral joint pathologies [2]. Chronic shoulder pain that does not respond to either conservative management (oral anti-inflammatory medications, physical therapy, and targeted steroid or local anesthetic injections) or to surgical interventions is referred to as chronic refractory shoulder pain. Neuromodulation, with either a peripheral nerve stimulator (PNS) or with pulsed radiofrequency (p-

RF), remain the only viable therapeutic options for such patients.

## CASE REPORT

This is a retrospective case series and approval was obtained from the Institutional Review Board of Benefis Health System (IRB No. 041720). Informed consent was waived due to the retrospective nature of the study. All patients having shoulder pain for more than 6 months, who had previously failed both conservative management and surgical treatment and who had subsequently been treated with neuromodulation of the suprascapular

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Correspondence to: Saugat Dey

Center for Pain and Spine, Dartmouth-Hitchcock Medical Center, 7 Timberwood Drive, Apt 230, Lebanon, NH 03766, USA

Tel: +1-267-736-0286, Fax: +1-6036506322, E-mail: [saugatharidwar@gmail.com](mailto:saugatharidwar@gmail.com), ORCID: <https://orcid.org/0000-0003-4128-3337>

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nerve by the same pain physician between July 1, 2017 and March 31, 2020, were included in the review. Patients were excluded if they did not follow up with a neuromodulation procedure at 1-, 3-, and 6-month intervals. Patients were also excluded if their Numeric Pain Score or self-reported functional assessment was not available for any of the follow-up visits. **Table 1** delineates the process of patient selection for the retrospective case series.

All patients demonstrated >50% temporary pain relief with ultrasound guided diagnostic suprascapular nerve blocks with 2 mL of 0.25% bupivacaine and 40 mg of triamcinolone prior to their neuromodulation procedures. The neuromodulation procedures were performed using ultrasound guidance under aseptic precautions. The patients were placed in a prone position and a linear transducer was placed oblique to the scapular spine. The hyperechoic suprascapular nerve was localized in the suprascapular fossa. The nerve was accessed using a lateral to medial in-plane approach. Nerve position was acquired using confirmation of optimal sensory and motor stimulation via demonstration of paresthesia over the shoulder area and contractions in the supraspinatus muscles, respectively.

All patients who were treated with neuromodulation first underwent a psychological screening to rule out any uncontrolled mental health or substance use problems as well as unrealistic treatment expectations. Patients treated with PNS were implanted with the Bioness Stimrouter (Bioness Inc., Valencia, CA, USA) lead using local anesthetic and light sedation as needed. An external pulse generator was used to power and regulate the lead, and it was affixed to the skin overlying the receiver end of the lead. For patients treated with p-RF after using local anesthetic, a 20-G 100-mm curved tip radiofrequency cannula with a 10-mm

active tip (Avanos Medical, Alpharetta, GA, USA) was used to perform two sets of treatments for 120 seconds each at a frequency of 2 Hz and a pulse width of 20 ms at 42°C.

### Case 1

A 65-year-old female presented with gradually worsening left shoulder pain which started insidiously 5 years ago. The patient was under the care of orthopedics specialists and magnetic resonance imaging (MRI) of the shoulder revealed a torn rotator cuff with degenerative joint disease of the glenohumeral and acromioclavicular joints. Her pain had failed to respond to oral nonsteroidal anti-inflammatory drugs (NSAIDs) and physical therapy. Rotator cuff repair with distal clavicle resection was performed but was not beneficial. Pain relief was also not obtained after a glenohumeral joint steroid injection. After evaluation in the pain clinic and a left suprascapular nerve diagnostic block, she underwent a PNS implant. Her baseline pain score was 7/10 and she was painless, i.e., pain score 0/10, at the 1-, 3- and 6-month follow-up visits. The patient also reported an 80% improvement in function at 1-month and 70% improvement at the 3-month and 6-month visits.

### Case 2

A 45-year-old female presented with right shoulder pain which started after lifting a heavy load 2 years ago. She underwent conservative treatments including NSAIDs, physical therapy, and aquatic therapy which provided minimal pain relief. An MRI of the shoulder demonstrated a rotator cuff tear with acromioclavicular joint hypertrophy. The patient was evaluated by orthopedics specialists as a poor surgical candidate due to her history of obesity and diabetes. The patient was referred to the pain clinic,

**Table 1.** The process of selecting patients for the retrospective case series

Inclusion criteria (must qualify every criterion to be included)	Exclusion criteria (will be excluded if meets any criteria)
<ul style="list-style-type: none"> <li>· Patient aged above 18 years</li> <li>· Patient was seen by author at the pain clinic.</li> <li>· Patient was experiencing shoulder pain for more than 6 months.</li> <li>· Patient's shoulder pain didn't improve with conservative management.</li> <li>· Patient's shoulder pain didn't improve with surgical interventions or patient wasn't considered a surgical candidate.</li> <li>· Patients had &gt; 50% temporary pain relief with ultrasound guided diagnostic suprascapular nerve blocks prior to their neuromodulation procedures.</li> <li>· Patient was treated with either pulsed radiofrequency therapy or peripheral nerve stimulation implant of suprascapular nerve by author.</li> <li>· Patient had followed up visits with author post neuromodulation procedure at 1-, 3-, and 6-month intervals.</li> </ul>	<ul style="list-style-type: none"> <li>· Patient had neuromodulation of multiple nerves, i.e., both suprascapular nerve and axillary nerve.</li> <li>· Patient had at least one missing Numeric Pain Score and/or a self-reported functional assessment score for the post procedural follow-up visits.</li> </ul>

and a right acromioclavicular joint steroid injection was initially performed which was not beneficial. Due to some clinical concern for subacromial bursitis, an ultrasound guided subacromial bursa injection was subsequently performed which provided only a few days of pain relief. At this point, right suprascapular nerve block was performed which was diagnostic and the patient elected to proceed with a p-RF treatment. The patient's pre-neuromodulation pain score was 9/10 and it improved to 1/10 at 1- and 3-month follow-up visits. However, the pain returned to the baseline score of 9/10 at the 6-month follow-up. The patient reported a 60% improvement in function at 1-month, 25% improvement at 3-months, and a return to baseline (0% improvement) at the 6-month visit.

**Case 3**

A 52-year-old female presented with insidious onset and gradually worsening left shoulder pain for the last 9 years. The patient was diagnosed with adhesive capsulitis. Physical therapy was not beneficial. She underwent left shoulder capsular release and subacromial bursectomy which provided pain relief for only 1 month. Repeat shoulder MRI only showed post-surgical changes and no further surgeries were recommended by orthopedics specialists. The patient was on oral opioid therapy for a few years which was not beneficial and was subsequently tapered off. Patient was seen in the pain clinic and after a diagnostic left suprascapular nerve block, she decided to proceed with a PNS implant. Post PNS, her pain score improved from baseline 10/10 to 0/10 at 1-month, and to 1/10 at both 3- and 6-month follow-up visits. Her self-reported functional improvement was 75% at 1-month, 70% at 3-month, and 60% at the 6-month visit.

**Case 4**

A 40-year-old female presented with non-traumatic right shoulder pain which started 20 years ago and worsened recently. Physical therapy and oral NSAIDs were somewhat beneficial. An MRI of the shoulder showed subacromial bursitis. A subacromial bursa injection under ultrasound provided only a few weeks of pain relief. She was evaluated by orthopedics specialists and no surgeries were recommended. Right suprascapular nerve block was diagnostic and the patient opted to proceed with p-RF treatments. the patient experienced improvement in pain scores from 6/10 pre-procedure to 4/10 at 1-month with return to baseline pain at 3-month and 6-month follow-up visits. Self-reported percentage improvement in function was 20% at 1 month with no improvement subsequently.

Table 2 delineates the clinical summary of all patients. No patient reported any immediate or late complications. However,

**Table 2.** Clinical summary of all cases

Variable	Case 1	Case 2	Case 3	Case 4
Age (yr)	65	45	52	40
History of shoulder pain (yr)	5	2	9	20
Diagnosis	Rotator cuff tear and degenerative joint disease	Rotator cuff tear with acromioclavicular joint hypertrophy	Adhesive capsulitis	Subacromial bursitis
Baseline self-reported pain NRS	7	9	10	6
Type of neuromodulation modality	Peripheral nerve stimulation	Pulsed radiofrequency	Peripheral nerve stimulation	Pulsed radiofrequency
One-month self-reported pain NRS	0	1	0	4
One-month self-reported functional improvement from baseline	80% Improvement	60% Improvement	75% Improvement	20% Improvement
Three-month self-reported pain NRS	0	1	1	6
Three-month self-reported functional improvement from baseline	70% Improvement	25% Improvement	70% Improvement	0% Improvement
Six-month self-reported pain NRS	0	9	1	6
Six-month self-reported functional improvement from baseline	70% Improvement	0% Improvement	60% Improvement	0% Improvement

NRS: numeric rating scale.

both patients treated with PNS (cases 1 and 3) reported the need for frequent charging of the external pulse generator which resulted in some interruption of their treatment.

### Literature Review

After searching Medline and Google Scholar databases, six randomized controlled trials (RCT) on p-RF therapy involving the suprascapular nerve were found and are summarized in Table 3 [3-8]. Most patients in these studies noted improvement in pain, disability scores, and shoulder joint range of motion from their baseline to post p-RF therapy. However, when we analyzed the superiority of p-RF over other comparative modalities for improvement in chronic shoulder pain, the results were mixed. P-RF was statistically superior to intra-articular steroid injection [3], physical therapy alone [6], and lidocaine only [8] nerve block for a maximum duration of 12 weeks or 3 months. However, p-RF was not significantly superior to transcutaneous electrical nerve stimulation at 12 weeks [4], lidocaine only nerve block at 6 months [5], or photobiomodulation therapy at 6 months [7].

There were no RCTs found that assessed the efficacy of PNS therapy to the suprascapular nerve in chronic refractory shoulder pain patients. Table 4 lists all four clinical reports obtained for

stimulator implants on the suprascapular nerve [9-12]. Among the two case reports listed: one patient had no pain at rest and excellent shoulder joint range of motion at the 3-month follow-up [9], while the other had no pain and did not require any pain medications at 9 months post-implantation [11]. There was also a large prospective case series which included one patient who underwent an implant on the suprascapular nerve and experienced 66.7% improvement in pain scores and 80% improvement in movement capacity [12]. Lastly, there was a retrospective case series in which a subset of nine patients underwent suprascapular nerve stimulator implant: pain score improved >50% for eight patients, mean pain improvement was 70%, and 6 patients had >50% improvement at last follow-up which was between 2 to 4 years [10].

## DISCUSSION

In this case series, the suprascapular nerve was the target of neuromodulation over the axillary nerve as the suprascapular nerve comprises 70% of sensory supply to the shoulder joint, the capsule, and the overlying skin as well as providing motor innervation to two of the rotator cuff muscles [13]. The analgesic action

**Table 3.** Summary of published randomized controlled trials on p-RF therapy of suprascapular nerve

First author (year of publication)	Group	Follow-up	Outcome measure	Result
Eyigor (2010) [3]	a. p-RF, n = 25 b. Intra-articular corticosteroid, n = 25	12 wk	VAS, ROM, SPADI, short-form 36, Beck depression scale questionnaires	p-RF group had significant improvement in VAS at rest at weeks 1 and 4, VAS at movement at week 1, and VAS at night at weeks 1, 4, and 12. p-RF group had significant improvement in SPADI at weeks 1, 4, and 12. p-RF group had significant improvement in active and passive abduction at weeks 1 and 4.
Korkmaz (2010) [4]	a. p-RF, n = 20 b. Transcutaneous electrical nerve stimulation, n = 20	12 wk	VAS, ROM, SPADI, short-form 36	p-RF group had significant improvement in SPADI at week 1.
Gofeld (2013) [5]	a. p-RF, n = 12 b. Nerve block with lidocaine, n = 10	6 mo	NRS, LSI, SPADI, CMS	No significant difference between both groups for NRS, SPADI, and CMS p-RF group had significant improvement in LSI at months 1 and 3.
Wu (2014) [6]	a. p-RF+12-week PT, n = 21 b. 12-week PT, n = 21	12 wk	VAS, ROM, SPADI	p-RF group had significant improvement in VAS score, SPADI score, and passive ROM at weeks 1, 4, 8, and 12.
Ökmen (2017) [7]	a. p-RF, n = 30 b. Photobiomodulation therapy, n = 29	6 mo	VAS, SPADI, Nottingham Health Profile score	No significant difference between both groups for any outcome measure
Alanbay (2020) [8]	a. p-RF, n = 15 b. Nerve block with lidocaine, n = 15	3 mo	VAS, ROM, GAS during upper-body dressing	p-RF group had significant improvement in VAS score and ROM at months 1 and 3. p-RF group had significant improvement in GAS at month 3.

p-RF: pulsed radiofrequency, VAS: visual analog scale, ROM: range of motion, SPADI: Shoulder Pain Disability index score, NRS: numeric rating scale, LSI: Likert scale index, CMS: Constant-Murley Score, PT: physical therapy, GAS: Goal Attainment Scale.

**Table 4.** Summary of published clinical reports and studies on peripheral nerve implant of suprascapular nerve

First author (year of publication)	Type of study, number of participants	Follow-up	Outcome measure	Result
Elahi (2014) [9]	Case report, 1	3 mo	Pain score, range of motion	Patient had no pain at rest and had excellent range of motion.
Bouche (2017) [10]	Retrospective case series, 9 patients with suprascapular implant	Mean, 33.6 mo; median, 27 mo	Quantitative improvement in pain	Mean pain improvement was 70%. At last follow-up, 6 patients had > 50% pain improvement.
Kurt (2016) [11]	Case report, 1	9 mo	Pain score, requirement of pain medications	Patient had no pain and had no requirement to take pain medications.
Oswald (2019) [12]	Prospective case series, 1 patient with suprascapular implant	3–6 mo	VAS pain score, activity, opioid consumption	Patient had 66.7% improvement in VAS, 80% improvement in activity, and no change in opioid consumption.

VAS: visual analog scale.

of PNS therapy is multi-modal and acts both via peripheral and central analgesic mechanisms including modulating inflammatory pathways, the autonomic nervous system, the endogenous pain inhibition pathways, with the involvement of cortical and subcortical areas [14]. p-RF therapy, which involves delivering rapid bursts of electromagnetic fields to the target, is known to enhance the descending pain inhibitory pathways [15].

In our retrospective case series, all patients had both neuromodulation interventions as well as pre-procedural diagnostic nerve blocks performed under ultrasound guidance. Ultrasound was chosen over fluoroscopy guidance as it provides direct real-time nerve visualization, more rapid onset of analgesia, better precision, involves limited trauma, and also reduces radiation exposure [16]. To avoid interoperator variability that might confound the comparison of results, neuromodulation procedures were performed by a single pain practitioner. Also, only patients with complete data for all three 1-, 3-, and 6-month follow-up windows were included in the case review.

A comparison between the two neuromodulation therapy techniques showed the two patients undergoing PNS therapy had better outcomes than the two patients with p-RF therapy, in terms of both numeric pain rating and functional improvement—especially at the 6-month interval. However, this study's sample size is too small to establish any clinically significant superiority for either therapy.

This study is a retrospective case report and hence the evidence obtained is less robust compared to that obtained with a prospective trial. Also, the small sample size and lack of racial or sex diversity in the sample makes generalization of the study results to the general population difficult. The follow-up period was limited to 6 months, therefore assumptions about the longer term effectiveness of the neuromodulation techniques cannot be made.

Peripheral nerve implant to the suprascapular nerve as well as

p-RF therapy of the nerve can both be effective therapeutic options for chronic refractory shoulder pain patients. This study reveals that PNS implants may be effective longer-term than p-RF treatment which tends to significantly lose its therapeutic effect post the 3-month follow-up interval. However, the small sample size and retrospective nature of this study makes it difficult to reach any definitive conclusions about the superiority of either of these therapies. Thus, we need larger RCTs to compare these two neuromodulation modalities involving the suprascapular nerve in order to build a robust treatment plan for chronic refractory shoulder pain patients.

## ORCID

Saugat Dey

<https://orcid.org/0000-0003-4128-3337>

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# Complications of reverse shoulder arthroplasty: a concise review

Su Cheol Kim, Il Su Kim, Min Chang Jang, Jae Chul Yoo

*Department of Orthopedic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea*

Reverse shoulder arthroplasty is an ideal treatment for glenohumeral dysfunction due to cuff tear arthropathy. As the number of patients treated with reverse shoulder arthroplasty is increasing, the incidence of complications after this procedure also is increasing. The rate of complications in reverse shoulder arthroplasty was reported to be 15%–24%. Recently, the following complications have been reported in order of frequency: periprosthetic infection, dislocation, periprosthetic fracture, neurologic injury, scapular notching, acromion or scapular spine fracture, and aseptic loosening of prosthesis. However, the overall complication rate has varied across studies because of different prosthesis used, improvement of implant and surgical skills, and different definitions of complications. Some authors included complications that affect the clinical outcomes of the surgery, while others reported minor complications that do not affect the clinical outcomes such as minor reversible neurologic deficit or minimal scapular notching. This review article summarizes the processes related to diagnosis and treatment of complications after reverse shoulder arthroplasty with the aim of helping clinicians reduce complications and perform appropriate procedures if/when complications occur.

**Keywords:** Arthroplasty; Complications; Replacement; Rotator cuff tear; Rotator cuff tear arthropathy; Shoulder

## INTRODUCTION

Reverse shoulder arthroplasty (RSA) was developed initially as a salvage procedure for cuff tear arthropathy; however, its use has been extended to other shoulder conditions, such as irreparable rotator cuff tear, glenohumeral osteoarthritis, proximal humerus fracture, and failed anatomical shoulder arthroplasty [1]. The surgical outcome of RSA is promising, and the technique has been increasingly used [2,3]. However, with increasing application of RSA, the number of complications has increased, which

occasionally requires interventions [3].

The rate of complications with RSA is approximately 15%–24% [3-6]. The complication rate differs among studies because of different definitions of complications and different prostheses used [6]. Some authors reported only major complications that affect the clinical outcome. Other studies reported both major and minor complications, including reversible neurologic deficit and minimal scapular notching [3,6-8].

The incidence of complications has changed over time. According to a systemic review conducted by Zumstein et al. [6] in

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Correspondence to: Jae Chul Yoo

Department of Orthopedic Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Korea

Tel: +82-2-3410-3501, Fax: +82-2-3410-0061, E-mail: [shoulderyoo@gmail.com](mailto:shoulderyoo@gmail.com), ORCID: <https://orcid.org/0000-0001-8378-1583>

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2011, the most common complication of RSA is instability (6.9%), followed by infection (5.6%), aseptic glenoid loosening (5.0%), acromion/scapular spine fracture (2.2%), glenoid or humeral disassembly (2.2%), humeral fracture (2.1%), humeral loosening (1.9%), and neurologic complications (1.7%). However, Ascione et al. [5] reported in 2018, a total complication rate of 18.7% in 1,035 cases of RSA in a 5-year follow-up study. They reported that infection (4.1%) was the most common complication, followed by instability (3%), neurologic complications (2.1%), glenoid complications (2.3%), and scapular fractures (1.1%). With improvements in prosthesis design and surgical skills, the rate of infection seems to be outpacing the rate of dislocation after RSA.

In our clinic, 438 RSAs were performed between March 2009 and December 2019, and 40 cases of complications were reported. The total complication rate after RSA was 9.1%. The most common complication was intraoperative humerus fracture (3.2%), followed by periprosthetic joint infection (1.1%), acromion/scapular spine fracture (1.1%), neurologic complications (0.7%), and dislocation (0.5%). In addition, minor problems including grade 1 or higher scapular notching (32.7%) and stress shielding of humerus (26.3%) were observed in our clinic. The purpose of this article is to describe the complications after RSA with the aim to provide information to help clinicians manage RSA-related complications.

## DISLOCATION

Dislocation is a common complication after RSA and requires surgical intervention in the early period (<2 years) [3,5,6,9]. The incidence of dislocation was reported to be 4.7% by Zumstein et al. [6]. A recent systemic review stated that dislocation was the second most common complication [5]. With improvements in RSA prosthesis design and surgical skills, the incidence of early dislocation after RSA seems to be decreasing. However, dislocation remains a difficult complication to correct because of the high failure rate after reoperation. Chalmers et al. [10] reported that 85% of primary RSA cases and more than 50% of revision RSA cases had successful outcomes after revision surgery.

There are multiple predisposing factors for early dislocation; therefore, it is important to determine the main cause of dislocation before reoperation. Previous surgery, including anatomical total shoulder arthroplasty and hemiarthroplasty, is a risk factor for dislocation after RSA [9,11]. The lack of soft tissue tension due to implant malposition, improper version of implant, and mechanical impingement [9,11,12] as well as subscapularis deficiency in medialized prosthesis design are known risk factors for

dislocation [9,11,12]. If early dislocation is caused by improper humeral or glenoid implant version, reoperation must be performed to normalize the implant version [9]. The humeral implant version can be measured by torsional-computed tomography including the elbow joint.

Deltoid tension is increased by glenoid lateralization and humerus distalization [9,11]. In cases of excessive medialization of the center of rotation, lateralization of the glenoid should be performed [9]. When humeral medialization is less than 15 mm, a larger or lateralized glenosphere or lateralizing is a choice [9,13,14]. However, when these options are not sufficient because of severe deficiency of the glenoid bone stock, bony increased offset-reversed shoulder arthroplasty is an option [9,11].

Humeral distalization is determined by humeral length and glenosphere position/size. Humeral length can be shortened if the original length is not restored. In proximal humeral bone loss such as proximal humerus fracture, revision RSA, osteolysis of proximal humerus, or overcutting of the humeral head in primary RSA, restoring the original length is challenging. If humeral height is short compared with the normal opposite side on plain radiograph, it can be increased using a thick polyethylene liner or thick metal tray (Fig. 1) [9,10,14]. However, the typical increase in height is 15–20 mm and differs by prosthesis [9]. If the height reduction exceeds 15–20 mm compared with the humeral



**Fig. 1.** Early dislocation after reverse shoulder arthroplasty (RSA). (A) Anteroposterior (AP) radiograph after primary RSA. AP (B) and scapular (C) Y-views showed anterior dislocation (arrows) of the humeral prosthesis at 4 months after surgery. (D) Revision RSA with polyethylene liner change was performed, and no dislocation had recurred over 2 years of follow-up.

length on the opposite side, humeral stem revision for height restoration using a cemented stem or structural humeral bone graft should be considered [3,9]. In addition, using a larger glenosphere and placing a glenosphere inferiorly can generate humerus distalization and increased deltoid tension.

Late dislocation can be caused by a change in implant position. There are many causes of implant position change, such as subsidence or rotation of the humeral stem and baseplate movement. Implant loosening can be detected by serial radiograph during follow-up and can arise from aseptic or septic loosening. Aseptic humeral loosening can be caused by stress shielding of the humerus or polyethylene debris of scapular notching [5]. Cases of glenoid baseplate loosening have been reported; however, in RSA, the rate of aseptic loosening of the baseplate was lower than that of the humeral stem [5,9]. Because of medialization of the glenoid in RSA, torque stress was lower on the glenoid side than on the humeral side [9,15]. In cases of implant loosening by periprosthetic infection, two-stage revision is the treatment of choice.

Subscapularis restoration also affects dislocation. The subscapularis is considered a protector of anterior dislocation in medialized RSA design [9,11,12]. In lateralized RSA design, horizontal deltoid compression stabilizes the shoulder joint; therefore, subscapularis repair is not required to prevent shoulder dislocation [16]. However, a recent meta-analysis showed that subscapularis repair reduces the rate of dislocation regardless of implant design [17]. Surgeons should assess the subscapularis tendon before the operation and consider implant design and position to prevent dislocation after surgery.

## PERIPROSTHETIC JOINT INFECTION

Periprosthetic joint infection has been the second most common complication of RSA, with an incidence rate ranging from 1% to 10% [5,6]. However, given the recent decrease in rate of dislocations, infection has become the most common complication [5]. Ascione et al. [5] reported a 4.1% rate of periprosthetic infection, which was the most commonly observed complication in 1,035 RSAs with an at least 5-year follow-up in 2018. In addition, Portillo et al. [18] reported that prosthesis failure within 2 years of implantation is a strong indicator of infection. Also, periprosthetic joint infection is the most common reason for revision arthroplasty within 2 years after RSA [19].

One predisposing factor for infection after RSA is prior shoulder surgery [11]. Previous arthroscopic rotator cuff repair is related to increased infection rates [9,11]. Other predisposing factors include morbid obesity (body mass index  $>40 \text{ kg/m}^2$ ), uncontrolled diabetes (glucose  $>200 \text{ mg/L}$ , hemoglobin A1C  $>7\%$ ), rheumatoid ar-

thritis, malnutrition, young age ( $<65$  years), intravenous drug abuse, long operation time ( $>115$  minutes), and number of times the surgical room door was opened during surgery [9,20,21].

Unlike hip and knee arthroplasty, in shoulder arthroplasty, the most commonly isolated organism is *Cutibacterium acnes* (formerly *Propionibacterium acnes*) (38.9%) [12,22-24]. This lipophilic and anaerobic non-spore forming Gram-positive rod-shaped bacteria is part of the normal flora of human skin [23-25]. In the deep dermis, the bacteria digests the sebum and secretes free fatty acids on the skin, generating the overall acidic environment of the skin [23]. The bacterial burden of *C. acnes* is higher in the anterior and posterior acromion and the axilla compared to other skin areas [26]. Men have a higher bacterial burden on the shoulder than women [25].

*C. acnes* is a slow-growing organism, and it takes 10–14 days to detect positive results from culture [27]. In addition, the bacteria produces biofilms on the body and metal prostheses, disturbing phagocytosis [27]. Patients with *C. acnes* infection present with unexplained continuous shoulder pain, stiffness, and osteolysis without overt signs of infection, such as swelling, redness, heat sensation, and effusion [23-25,28]. *Staphylococcus epidermidis* (14.8%) and *Staphylococcus aureus* (14.5%) are other commonly observed organisms [9,11,12].

Many strategies can be used for prevention of periprosthetic infection. Bathing with chlorhexidine gluconate on the day before surgery reduces the risk of infection [22,29]. Hair shaving before surgery is not necessary [30]. Administration of first-generation cephalosporin as a preventive antibiotic 1 hour before surgery is recommended; however, *C. acnes* will not be completely eliminated from the surgical field [31]. During skin preparation, chlorhexidine must be allowed to dry completely before draping [32]. Benzoyl peroxide recently has been reported to effectively decrease the burden of *C. acnes* [24]. Laminar flow in the operating room was ineffective for reducing risk, but reducing the number of times the surgical room doors were opened during surgery helps reduce the risk of infection [33]. Changing surgical gloves regularly, changing the blade after skin incision, frequent surgical site irrigation, irrigation with diluted povidone (1.3 g/L), injection of gentamicin at the time of closure, use of antibiotic-loaded cement (1 g of vancomycin/bone cement), and use of topical adhesives for skin closure were reported to be effective in decreasing the risk of infection after arthroplasty [18-20,34-36].

If patients have purulent joint fluid with pus discharge fistula, diagnosis of periprosthetic joint infection is not difficult. However, in cases of low-grade infection without joint fluid or normal infection markers on laboratory tests, intraoperative biopsy and

culture play a crucial role in diagnosis [37]. Tissue biopsy is more accurate than fluid aspiration; biopsy tissue culture has 100% sensitivity and 100% specificity, while aspirate culture has 16.7% sensitivity and 100% specificity [37]. In addition, Hsu et al. [22] recommended harvesting a minimum of five biopsy samples during surgery for *C. acnes* culture.

The preferred management strategy for infected RSA remains controversial [34]. In cases of acute infection (<6 weeks), open irrigation and debridement with exchange of modular components are regarded as standard treatment [38]. However, the results of this treatment strategy are not conclusive. Ortmaier et al. [36] reported a success rate of 50% (2/4) with prior treatment, and patients with failure required additional surgery. In cases of chronic infection, traditional two-stage revision is the gold standard treatment for periprosthetic joint infection [12,36,39]. Two-stage revision showed an infection recurrence rate of 0%–36% [40]. This strategy shows the best result in terms of eradication of infection, pain relief, and restoration of function but requires a long treatment time (Fig. 2) [41].

Some short-duration treatment procedures have been attempted to reduce treatment time and patient discomfort. Debridement and retention of the prosthesis have been attempted, but have not shown consistent satisfactory results [9,34]. In a French multicenter study, among 17 patients who underwent debridement and partial component retention, 7 showed clearance of infection [42], and Romanò et al. [34] reported unsatisfactory results after component retention. One-stage exchange has been gaining attention for its advantages of reduced dissection length, reduced stress to soft tissues, and reduced time and costs [40]; furthermore, Klatte et al. [43] reported a 94% success rate with a mean follow-up period of 4.7 years. In a systematic review, both one- and two-stage exchange provided greater than 85% eradication rates [41]. In addition, cement spacers could be a long-term treatment option for joints with low functional demands [41,44].

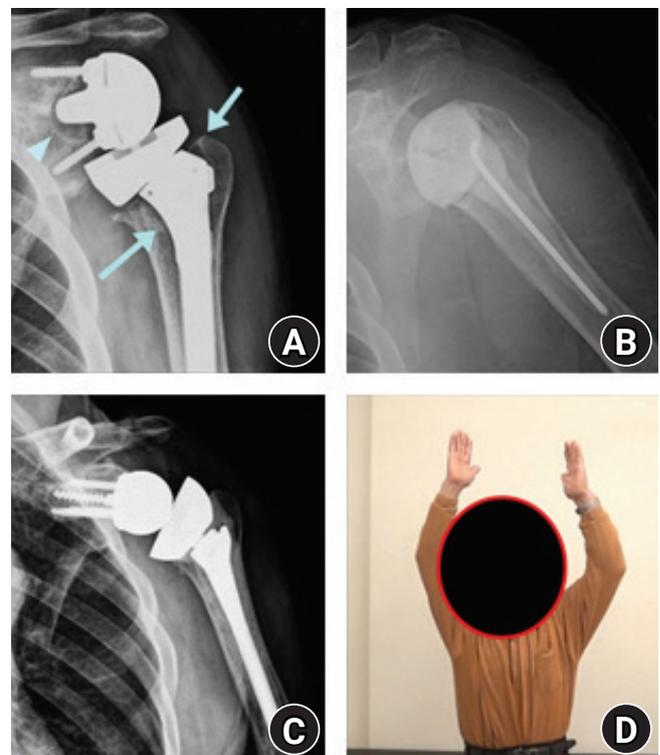
## INTRAOPERATIVE FRACTURE

Intraoperative fractures can occur on the humeral or glenoid side during surgery. Both types of fracture are uncommon complications during surgery but are difficult to manage. Boileau et al. [45] reported one case of perioperative humeral fracture and one case of intraoperative glenoid fracture in 45 patients over a mean follow-up of 40 months. In a review article by Zumstein et al. [6], the rate of intraoperative humeral fracture was 2.0% (16/782), and that of intraoperative glenoid fracture was 0.9% (7/782).

Humeral side fractures during surgery are more common than glenoid fractures. A systemic review reported humeral side frac-

tures in 1.8% (91/5,539 shoulders) of patients [3]. In our clinic, intraoperative humeral fracture was observed in 3.2% of 438 RSAs. In particular, if a large press-fit stem (high filling ratio) [46] is used, the proximal humerus rim can be damaged during impaction. In addition, fractures occur frequently during arm positioning, such as extension, rotation, and translation, to dislocate or reduce the humeral head. During arm positioning, spiral fracture of the humeral metaphysis or greater tuberosity avulsion fracture could occur [47]. Other risk factors for intraoperative humeral fracture are osteopenia, rheumatoid arthritis, and revision surgery [47]. To prevent intraoperative humeral fractures, surgeons should be aware of the risk factors for periprosthetic fracture [48]. During humerus positioning, inferior capsular release from the humerus must be carried out. In addition, during implant insertion, broaching should be performed parallel to the humeral shaft, and excessive fitting of the humeral stem should be avoided.

The treatment plan for intraoperative humeral fracture must include fracture site, displacement, bone quality, and stability of



**Fig. 2.** Two-stage revision for infected reverse shoulder arthroplasty (RSA). (A) Anteroposterior radiograph of primary RSA after 18 months. Radiolucency around the humeral stem (arrows) at the metaphysis and glenoid baseplate (arrowhead) was observed. (B) Implant removal and anti-mixed cement spacer insertion was performed. (C) After infection control, revision RSA with cemented humeral stem was performed, and (D) greater than 120° of left shoulder elevation was achieved at 2 years after the final surgery (photograph used with permission for study purpose).

the humeral stem. If a displaced fracture occurs before humeral insertion or if impending fracture occurs without displacement, cerclage wiring can help stabilize the fracture site during subsequent procedures [49]. If a fracture occurs after humeral stem insertion, the stability of the humeral stem should be evaluated. In a stable humeral stem, cerclage wiring and additional fixation without stem change are sufficient, while unstable humeral stem requires repair with a long or cemented stem to achieve stability (Fig. 3) [49].

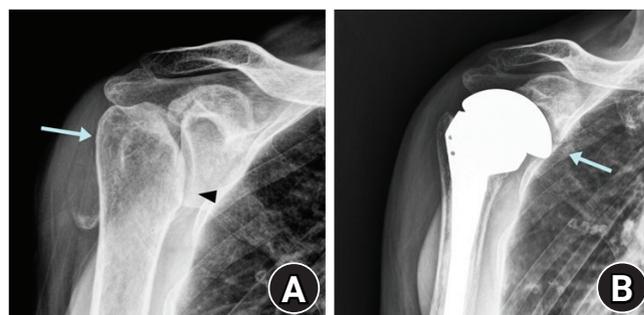
Intraoperative glenoid fractures rarely occur during surgery, with an incidence rate of 0.3% [3]. These fractures can occur during the reaming procedure or fixation of glenoid implants. In patients with osteoporosis, care must be taken during reaming and impaction of the baseplate. In addition, in patients with degenerative osteoarthritis, the glenoid can be fractured despite a high level of hardness [50]. This can be caused by decreased elasticity of the sclerotic bone. If an intraoperative fracture occurs, fixation with locking screws from the baseplate can be attempted, while small marginal fractures can be ignored [11]. However, if such fixation is not possible, fragment-specific fixation using a screw or wire is the second choice. In catastrophic glenoid failure, bone grafting and fixation of the glenoid implant should be discussed. These processes can be performed in one or two stages (prepare the bone graft and glenoid bone stock and re-implant the glenoid component). However, negative outcomes have been reported in cases of glenoid fracture [6].

Our first case of periprosthetic fracture was intraoperative glenoid fracture during trial reduction. This was the first case of RSA in our department for 12 years. Therefore, we had to convert to hemiarthroplasty, since our experience of RSA was limited (Fig. 4).

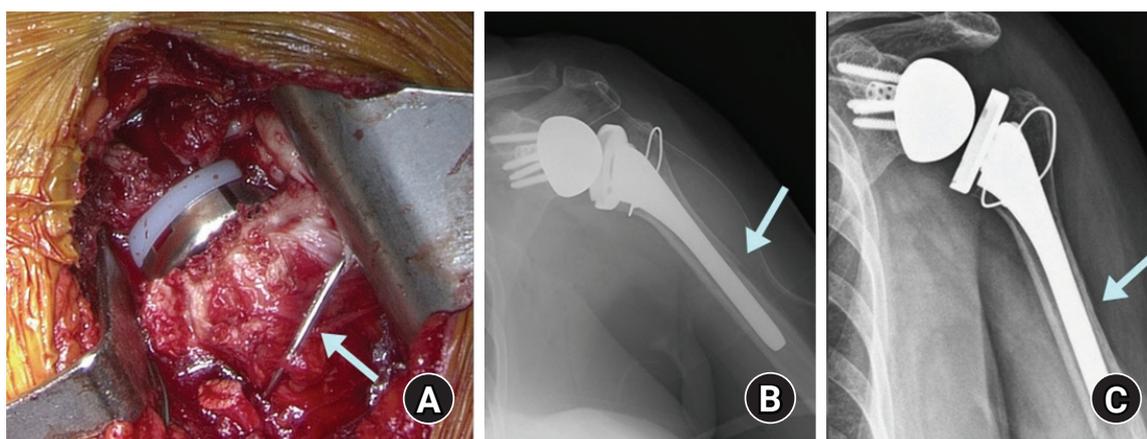
## ACROMION/SCAPULAR SPINE FRACTURE

Acromial or scapular spine fracture after RSA is a rare complication, with incidence rates ranging from 0.9% to 10% [11,15,51]. The acromion and spine of the scapula are the origins of the deltoid muscle. The mean arm length increases by 2.5 cm with distalization of the humerus, and the center of rotation is medialized after RSA, increasing the tension in the deltoid muscle [52]. In addition, during arm elevation after RSA, the deltoid muscle acts as an elevator, and the load on the acromion is increased. Increased tension and load can cause stress fracture of the acromion or scapular spine.

Initially, patients experience lateral shoulder pain with decreased shoulder function [11,12]. Moreover, the patients are not able to elevate their arm due to loss of tension in the deltoid muscle [11]. The fracture can be treated with conservative treatment,



**Fig. 4.** Intraoperative glenoid fracture during reverse shoulder arthroplasty. (A) Preoperative humeral head deformity (arrow) with glenohumeral joint space narrowing was observed (arrowhead). (B) Glenoid fracture occurred during the reduction procedure, and surgery was converted to hemiarthroplasty (arrow).



**Fig. 3.** Periprosthetic humeral fracture during reverse shoulder arthroplasty. (A) During surgery, the humeral spiral fracture was stabilized with cerclage wire (arrow), and the humeral stem was inserted with firm fixation. (B) Immediate postoperative anteroposterior radiograph showed fracture around the humeral stem (arrow). (C) The fracture was healed at 4 months after surgery (arrow).

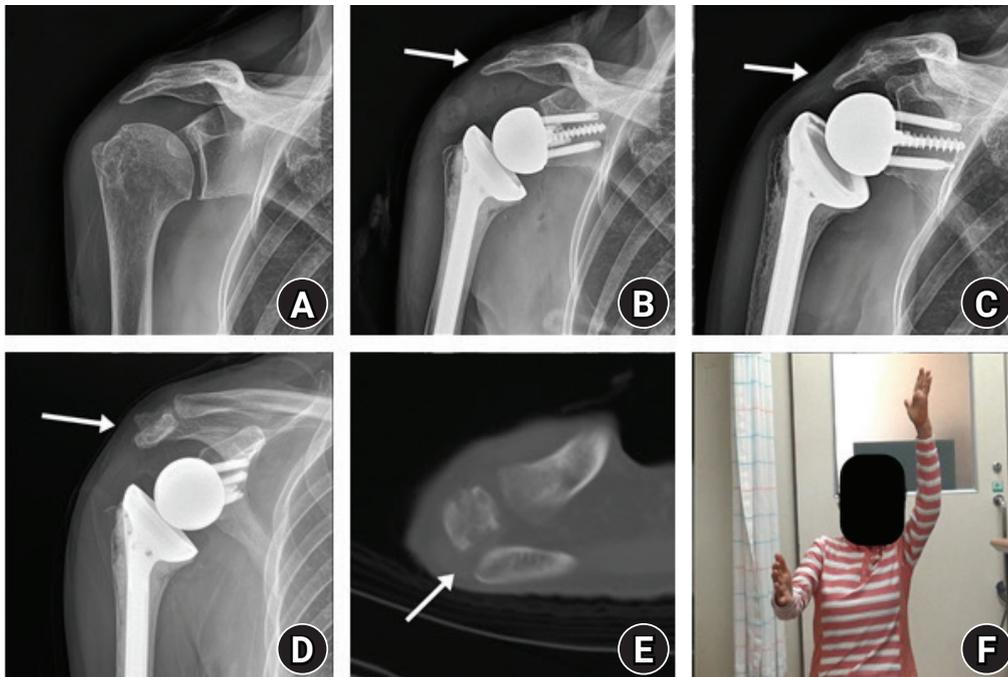
such as shoulder immobilization, or surgical treatment, but this is debated. Levy et al. [53] reported 18 cases of conservative treatment of acromion/spine fracture, and the patients showed decreased shoulder function, while Hatstrup [54] reported good results after conservative treatment of acromion/spine fracture. In scapular spine fracture, Crosby et al. [51] reported high non-union rate after conservative treatment and recommend surgical treatment with tension band wiring and buttress plate.

Osteoporosis and acromial erosion before surgery are risk factors for acromion or scapular spine fractures [11,12]. Excessive distalization of the humerus and medialization of the center of rotation result in high tension in the deltoid muscle. Hence, surgeons should not position the baseplate excessively inferiorly to avoid humeral overdistalization in patients with osteoporosis or a thin acromion. In addition, use of a lateralized-type prosthesis rather than a Grammont-type prosthesis is recommended to prevent overtension of the deltoid muscle. In addition, malpositioning of the superior or posterior baseplate screws is associated with scapular spine stress fracture [11]. Pointing the upper screw of the baseplate toward the coracoid base could prevent scapular spine fractures. During postoperative outpatient visits, surgeons should assess the serial changes in acromion tilt on plain radiography and should cautiously investigate percussion tenderness over the acromion.

We report two cases of an acromial stress fracture after RSA. The first patient recovered with conservative treatment, while the second patient required arthroscopic rotator cuff repair for a medium-sized rotator cuff tear with acromioplasty and did well for 5 years. The patient then complained of increasing right shoulder pain; hence, we performed RSA with a lateralized glenoid design. Before surgery, she had osteopenia (T-score,  $-0.6$ ) and her acromion was 4.8 mm thick. After surgery, the humerus was distalized by 2.4 cm. Four months after surgery, she developed new-onset lateral shoulder pain, and plain radiograph showed inferior tilt of the lateral acromion. Conservative management was performed for 2 years. Although shoulder function improved gradually, she showed a low degree of shoulder elevation (active forward elevation,  $80^\circ$ ) and low functional scores (Fig. 5).

## SCAPULAR NOTCHING

Scapular notching is a unique complication of RSA resulting from changes in the glenohumeral anatomical structure [55]. It is usually observed 6 months postoperatively on plain radiography, and the reported incidence of scapular notching ranges from 4.6% to 96% [6,8,11,56,57]. Scapular notching is the most commonly observed complication; hence, Zumstein et al. [6] classified this as a postoperative problem rather than a complication.



**Fig. 5.** Acromion fracture after reverse shoulder arthroplasty (RSA). (A) Initial anteroposterior (AP) radiograph and (B) early postoperative AP radiograph showed an intact acromion (arrow). (C) Acromial inferior tilt (arrow) was observed at 4 months after RSA. Two years after RSA, (D) inferior tilt of acromion (arrow) and (E) non-union of acromion (arrow) were observed on computed tomography. (F) The patient had decreased right shoulder elevation at 2 years after surgery (photograph used with permission for study purpose).

Notching refers to mechanical impingement of the humeral component at the scapular neck during extension and external rotation at the side [56]. The main position of notching is the posteroinferior aspect of the scapular neck, but it can occur at the anteroinferior aspect of the neck [56].

The occurrence of notching depends on multiple factors, such as implant design and position, patient anatomy, and range of motion [11,57]. The Grammont-type implant has a high tendency for scapular notching because of the large neck shaft angle of the humeral stem [56]. In a study by Kolmodin et al. [56], scapular notching was observed in 59% of cases with Grammont-type prostheses. A decreased humeral neck shaft angle tends to protect against scapular notching [58]. In addition, inferior glenosphere placement, inferior tilt, and lateralization of the center of rotation are thought to decrease the risk of notching [57].

Decreased scapular neck length (SNL) leads to an increased rate of scapular notching [59]. SNL is determined innately; however, it can be shortened by wear of the glenohumeral joint by cuff tear arthropathy or degenerative/inflammatory arthritis [57]. In cases of short SNL, glenoid lateralization using an eccentric glenosphere or glenoid augmentation should be considered [57,59].

The clinical course of scapular notching is debated [60]. Many studies have reported that patients without scapular notching showed better range of motion and functional outcomes than patients with scapular notching [57,60]. Mollon et al. [58] observed scapular notching with a single implant (medial glenoid/lateral humerus design) in 10% of 476 cases and found that patients with scapular notching showed poor functional scores, low degree of shoulder elevation, and reduced muscle strength [58].

In addition, patients with scapular notching showed significantly higher complication rates and tended to have significantly higher rates of humeral radiolucent lines than patients without scapular notching [58]. Notching grades 1 and 2 are thought to be caused by mechanical friction, while grades 3 and 4 are considered to be biological responses to polyethylene particles resulting from humeral or glenoid osteolysis [57]. Notching induces wear of the polyethylene, resulting in osteolysis of the glenohumeral joint [58].

There are a few methods to prevent scapular notching. Lateralization of the glenoid component is one method. When performing RSA in patients with SNL less than 9.0 mm, glenoid augmentation should be considered or an implant with increased lateral offset can be used [57]. In addition, use of an eccentric glenosphere is helpful [61]. Inferior overhang of the glenosphere of 3–4 mm prevents scapular notching [56,57]. Inferior tilt of the glenosphere by 15°–20° also prevents notching [61]; use of lateralized

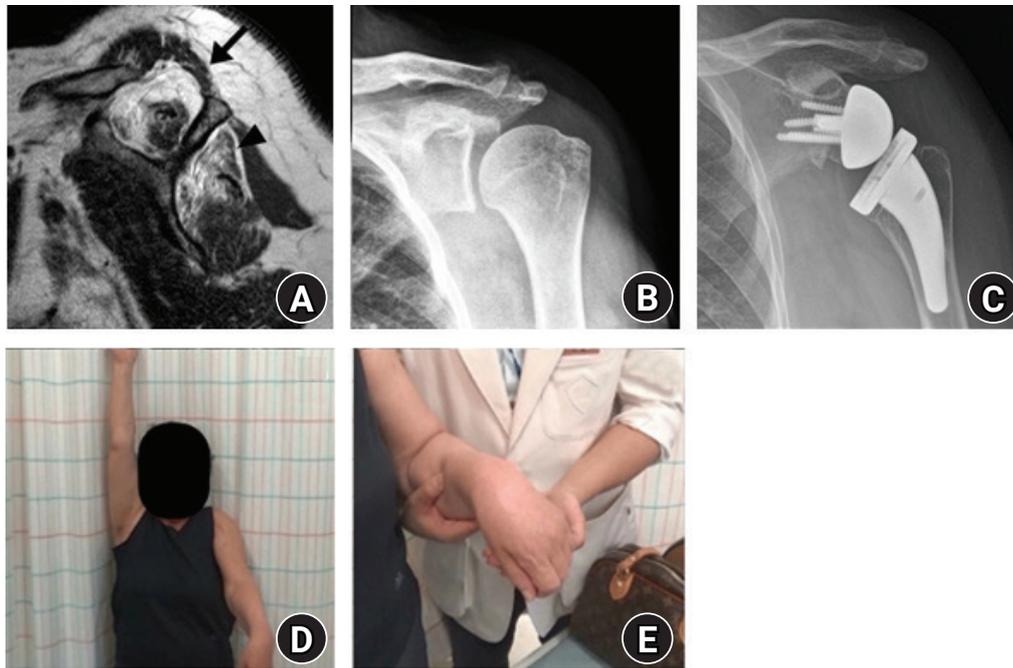
humeral prostheses increases postoperative external rotation and decreases the risk of scapular notching [13]. According to Ferrier et al. [62], the best clinical results and lowest incidence of scapular notching were found after lowering the humerus by more than 24 mm.

## NEUROLOGIC COMPLICATIONS

Most minor neurologic complications after RSA cannot be detected. The previously reported incidence of neurologic complications was 1%–4% after RSA [63]. Neurologic complications can occur during or after surgery. The most commonly injured nerves after RSA are the axillary nerve and brachial plexus [7,64]. In addition, suprascapular nerve and recurrent laryngeal/hypoglossal nerve injuries have been reported [65,66]. These injuries are generally reversible during the first 3 months after surgery, but some do not heal for long periods, resulting in neurologic deficits [11].

The axillary nerve originates from the posterior cord of the brachial plexus, runs anterior to the subscapularis, lies under the inferior capsule and glenoid rim, and runs through the quadrilateral space. Anatomically, the axillary nerve passes 3.2–12.4 mm below the inferior glenoid rim [65,67]. The nerve then divides into the anterior and posterior branches, and the anterior branch wraps the inner surface of the deltoid muscle, which is 5–7 cm distal to the lateral acromial border, and innervates the deltoid muscle [67–69]. Injury to the axillary nerve causes deltoid dysfunction, resulting in difficulty in elevating the shoulder. In addition, decreased anterior-to-posterior deltoid tension can cause instability [68]. Additionally, gross wasting of the shoulder, persistent shoulder pain, and impaired rehabilitation can be observed [68].

The most common site of injury to the axillary nerve during surgery is the inferior glenoid rim [65]. During glenoid preparation, iatrogenic injury can occur due to prolonged retraction and wide exposure with electrocautery [65]. Deep and sharp retractors such as the Hormann retractor should be used cautiously, and careful periosteal detachment of the capsulolabral tissue for glenoid preparation is necessary to prevent iatrogenic axillary nerve injury. However, axillary nerve injury can be difficult to detect immediately after surgery since the operated shoulder usually is immobilized. In addition, Läderrmann et al. [68] reported axillary nerve injury at the posterior humeral metaphyseal level. They found that the axillary nerve to the deltoid muscle is close to the posterior humeral component; therefore, caution should be exercised when cutting the humeral neck and reaming to avoid damage to the posterior humeral cortex.



**Fig. 6.** Brachial plexus injury after reverse shoulder arthroplasty. (A) Preoperative scapular Y-view of magnetic resonance imaging showed greater than 50% muscle atrophy in the supraspinatus (arrow) and infraspinatus (arrowhead). Preoperative (B) and postoperative (C) anteroposterior radiographs of the shoulder. (D) Decreased left shoulder elevation and (E) wrist drop sign were observed during follow-up, indicating brachial plexus injury (photographs used with permission for study purpose).

Injury to the brachial plexus can be caused by humerus positioning during surgery. During the deltopectoral approach, excessive humeral hyperextension, external rotation, and anterior translation of the humeral head can damage the brachial plexus [38]. Van Hoof et al. [70] reported a 15.3%–19.3% increase in strain at the median nerve root after surgery using a three-dimensional computer model. In addition, Lynch et al. [71] observed nerve injury during shoulder joint replacement surgery in 18 of 417 patients, and most injuries were neurapraxias from stretching injury due to positioning. Excessive humeral distalization also can cause traction injury of the brachial plexus during or after surgery [11,71].

We observed one case of brachial plexus palsy among 438 RSA cases; the patient recovered only partially after 3 years of follow-up. The patient was a 77-year-old woman who showed reduction in strength for shoulder elevation, wrist drop, and reduction in grasp power just after the surgery. Two years after surgery, a nerve conduction study showed a brachial plexus lesion (Fig. 6). One possible cause of injury was excessive positioning such as hyperextension, external rotation, and anterior translation during the humeral procedure. Since then, we have taken caution to avoid such situations. We have since performed RSA in 236 patients, and none experienced brachial plexus injury.

Malpositioning of screws can be associated with suprascapular nerve injury during glenoid fixation. Extraosseous placement of

superior and posterior screws can damage the suprascapular nerve at the scapular notch or spinoglenoid notch [11]. In addition, excessive head tilting during surgery could cause recurrent laryngeal nerve injury or hypoglossal nerve injury, resulting in Tappin's syndrome [66].

## CONCLUSION

Given the increase in number of patients undergoing RSA, the number of patients experiencing complications is increasing. Although it is difficult to manage complex complications after RSA, such as dislocation, infection, periprosthetic fracture, and aseptic loosening of the prosthesis, complications can be corrected by determining the underlying reasons and planning the treatment strategy accordingly. Importantly, surgeons should be cautious in addressing the pre- and intraoperative factors of complications to reduce the incidence of complications such as dislocation, scapular notching, and neurologic complications.

## ORCID

Su Cheol Kim  
Jae Chul Yoo  
Min Chang Jang  
Jae Chul Yoo

<https://orcid.org/0000-0001-9961-5547>  
<https://orcid.org/0000-0001-8378-1583>  
<https://orcid.org/0000-0002-3315-6082>  
<https://orcid.org/0000-0001-8378-1583>

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# Instructions to authors

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May 13, 2014

September 1, 2017

March 1, 2019

December 1, 2019

## 1. AIMS AND SCOPE

CiSE is an international, peer-reviewed journal and the official journal of Korean Shoulder and Elbow Society. It was first launched in 1998. It is published quarterly in the first day of March, June, September, and December, with articles in English, and has been published as an online-only journal since 2019.

The purpose of CiSE are: first to contribute in the management and education of shoulder and elbow topics; second, to share latest scientific informations among international societies; and finally to promote communications on shoulder/elbow problems and patient care. It can cover all fields of clinical and basic researches in shoulder and elbow.

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[www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/](https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/)). Clinical studies that do not meet the Helsinki Declaration will not be considered for publication. For human subjects, identifiable information, such as patients' names, initials, hospital numbers, dates of birth, and other protected health care information, should not be disclosed. For animal subjects, research should be performed based on the National or Institutional Guide for the Care and Use of Laboratory Animals. The ethical treatment of all experimental animals should be maintained.

### Statement of Informed Consent and Institutional Approval

Copies of written informed consent should be kept for studies on human subjects. Clinical studies with human subjects should provide a certificate, an agreement, or the approval by the Institutional Review Board (IRB) of the author's affiliated institution. For research with animal subjects, studies should be approved by an Institutional Animal Care and Use Committee (IACUC). If necessary, the editor or reviewers may request copies of these documents to resolve questions regarding IRB/IACUC approval and study conduct.

### Conflict of Interest Statement

The author is responsible for disclosing any financial support or benefit that might affect the content of the manuscript or might cause a conflict of interest. When submitting the manuscript, the author must attach the letter of conflict of interest statement ([http://cisejournal.org/authors/copyright\\_transfer\\_agreement.php](http://cisejournal.org/authors/copyright_transfer_agreement.php)). Examples of potential conflicts of interest are financial support from or connections to companies, political pressure from interest groups, and academically related issues. In particular, all sources of funding applicable to the study should be explicitly stated.

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plagiarism or duplicate publication using Crossref Similarity Check. If a paper that might be regarded as duplicate or redundant had already been published in another journal or submitted for publication, the author should notify the fact in advance at the time of submission. Under these conditions, any such work should be referred to and referenced in the new paper. The new manuscript should be submitted together with copies of the duplicate or redundant material to the editorial committee. If redundant or duplicate publication is attempted or occurs without such notification, the submitted manuscript will be rejected immediately. If the editor was not aware of the violations and of the fact that the article had already been published, the editor will announce in the journal that the submitted manuscript had already been published in a duplicate or redundant manner, without seeking the author's explanation or approval.

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Authorship credit should be based on (1) substantial contributions to conception and design, acquisition of data, and analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content; (3) final approval of the version to be published; and (4) agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Authors should meet these four conditions.

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- Correction of authorship: Any requests for such changes in authorship (adding author(s), removing author(s), or re-arranging the order of authors) after the initial manuscript submission and before publication should be explained in writing to the editor in a letter or e-mail from all authors. This letter must be signed by all authors of the paper. A copyright assignment must be completed by every author.
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details of authorship, ethics committee approval, clinical trial registration documentation, and conflict of interest forms and statements, are properly completed, although these duties may be delegated to one or more coauthors. The corresponding author should be available throughout the submission and peer review process to respond to editorial queries in a timely manner, and after publication, should be available to respond to critiques of the work and cooperate with any requests from the journal for data or additional information or questions about the article.

- Contributors: Any researcher who does not meet all four ICMJE criteria for authorship discussed above but contribute substantively to the study in terms of idea development, manuscript writing, conducting research, data analysis, and financial support should have their contributions listed in the Acknowledgments section of the article.

### Process for Managing Research and Publication Misconduct

When the journal faces suspected cases of research and publication misconduct, such as redundant (duplicate) publication, plagiarism, fraudulent or fabricated data, changes in authorship, undisclosed conflict of interest, ethical problems with a submitted manuscript, appropriation by a reviewer of an author's idea or data, and complaints against editors, the resolution process will follow the flowchart provided by COPE (<http://publicationethics.org/resources/flowcharts>). The discussion and decision on the suspected cases are carried out by the Editorial Board.

### Editorial Responsibilities

The Editorial Board will continuously work to monitor and safeguard publication ethics: guidelines for retracting articles; maintenance of the integrity of academic records; preclusion of business needs from compromising intellectual and ethical standards; publishing corrections, clarifications, retractions, and apologies when needed; and excluding plagiarized and fraudulent data. The editors maintain the following responsibilities: responsibility and authority to reject and accept articles; avoid any conflict of interest with respect to articles they reject or accept; promote the publication of corrections or retractions when errors are found; and preserve the anonymity of reviewers.

## 3. EDITORIAL POLICY

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### Registration of Clinical Trial Research

It is recommended that any research that deals with a clinical trial be registered with a clinical trial registration site, such as <http://cris.nih.go.kr>, <http://www.who.int/ictcp/en>, and <http://clinicaltrials.gov>.

### Data Sharing

ICiSE encourages data sharing wherever possible, unless this is prevented by ethical, privacy, or confidentiality matters. Authors wishing to do so may deposit their data in a publicly accessible repository and include a link to the DOI within the text of the manuscript.

- Clinical Trials: CiSE accepts the ICMJE Recommendations for data sharing statement policy. Authors may refer to the editorial, “Data Sharing statements for Clinical Trials: A Requirement of the International Committee of Medical Journal Editors,” in the *Journal of Korean Medical Science* (<https://dx.doi.org/10.3346/jkms.2017.32.7.1051>).

### Archiving Policy

CiSE provides electronic archiving and preservation of access to the journal content in the event the journal is no longer published, by archiving in the National Library of Korea. According to the deposit policy (self-archiving policy) of Sherpa/Romeo (<http://www.sherpa.ac.uk/>), authors cannot archive pre-print (i.e., pre-refereeing) but they can archive post-print (i.e., final draft post-refereeing). Authors can archive the publisher’s version/PDF.

## 4. SUBMISSION AND PEER-REVIEW PROCESS

### Submission

All manuscripts should be submitted online via the journal’s website (<https://submit.cisejournal.org/>) by the corresponding author.

Once you have logged into your account, the online system will lead you through the submission process in a stepwise orderly process. Submission instructions are available at the website. All articles submitted to the journal must comply with these instructions. Failure to do so will result in the return of the manuscript and possible delay in publication.

### Peer Review Process

All papers, including those invited by the Editor, are subject to peer review. Manuscripts will be peer-reviewed by two accredited experts in the shoulder and elbow with one additional review by prominent member from our editorial board. CiSE’s average turnaround time from submission to decision is 4 weeks. The editor is responsible for the final decision whether the manuscript is accepted or rejected.

- The journal uses a double-blind peer review process: the reviewers do not know the identity of the authors, and vice versa.
- Decision letter will be sent to corresponding author via registered e-mail. Reviewers can request authors to revise the content. The corresponding author must indicate the modifications made in their item-by-item response to the reviewers’ comments. Failure to resubmit the revised manuscript within 4 weeks of the editorial decision is regarded as a withdrawal.
- The editorial committee has the right to revise the manuscript without the authors’ consent, unless the revision substantially affects the original content.
- After review, the editorial board determines whether the manuscript is accepted for publication or not. Once rejected, the manuscript does not undergo another round of review.

### Appeals of Decisions

Any appeal against an editorial decision must be made within 2 weeks of the date of the decision letter. Authors who wish to appeal a decision should contact the Editor-in-Chief, explaining in detail the reasons for the appeal. All appeals will be discussed with at least one other associate editor. If consensus cannot be reached thereby, an appeal will be discussed at a full editorial meeting. The process of handling complaints and appeals follows the guidelines of COPE available from (<https://publicationethics.org/appeals>). CiSE does not consider second appeals.

## 5. MANUSCRIPT PREPARATION

Authors are required to submit their manuscripts after reading the following instructions. Any manuscript that does not conform to the following requirements will be considered inappropriate and may be returned.

## General Requirements

- All manuscripts should be written in English.
- The manuscript must be written using Microsoft Word and saved as “.doc” or “.docx” file format. The font size must be 12 points. The body text must be left aligned, double spaced, and presented in one column. The left, right, and bottom margins must be 3 cm, but the top margin must be 3.5 cm.
- The page numbers must be indicated in Arabic numerals in the middle of the bottom margin, starting from the abstract page.
- Neither the authors’ names nor their affiliations should appear on the manuscript pages.
- Only standard abbreviations should be used. Abbreviations should be avoided in the title of the manuscript. Abbreviations should be spelled out when first used in the text and the use of abbreviations should be kept to a minimum.
- The names and locations (city, state, and country only) of manufacturers of equipment and non-generic drugs should be given.
- Authors should express all measurements in conventional units using International System (SI) units.
- P-value from statistical testing is expressed as capital P.

## Reporting Guidelines for Specific Study Designs

For specific study designs, such as randomized control studies, studies of diagnostic accuracy, meta-analyses, observational studies, and non-randomized studies, authors are encouraged to consult the reporting guidelines relevant to their specific research design. A good source of reporting guidelines is the EQUATOR Network (<https://www.equator-network.org/>) and NLM ([https://www.nlm.nih.gov/services/research\\_report\\_guide.html](https://www.nlm.nih.gov/services/research_report_guide.html)).

## Composition of Manuscripts

- The manuscript types are divided into Original Article, Review Article, Case Report, and other types. There is no limit to the length of each manuscript; however, if unnecessarily long, the author may be penalized during the review process.
- Original Articles should be written in the following order: title page, abstract, keywords, main body (introduction, methods, results, discussion), acknowledgments (if necessary), references, tables, figure legends, and figures. The number of references is limited to 30.
- Review Articles should focus on a specific topic. Format of a review article is not limited. Publication of these articles will be decided upon by the Editorial Board.
- Case Reports should be written in the following order: title page, abstract, keywords, main body (introduction, case report, discussion), acknowledgments (if necessary), references, tables, figure legends, and figures. The number of references is limited to 10.

The Abstract should not exceed 200 words, and must be written as one unstructured paragraph. Authors are warned that these have a high rejection rate.

- Technical Notes should not exceed 1,500 words. The abstract should be an unstructured summary not exceeding 150 words. The body of these manuscripts should consist of introduction, technique, discussion, references, and figure legends and tables (if applicable). References should not exceed 10. A maximum of 3 figures and 1 table are allowed.
- Current Concepts deal with most current trends and controversies of a single topic in shoulder and elbow. Authors are recommended to update all the knowledge to most recent studies and researches.
- Systemic Review examines published material on a clearly described subject in a systematic way. There must be a description of how the evidence on this topic was tracked down, from what sources and with what inclusion and exclusion criteria.
- Meta-analysis: A systematic overview of studies that pools results of two or more studies to obtain an overall answer to a question or interest. Summarizes quantitatively the evidence regarding a treatment, procedure, or association.
- Letters to the Editor: The journal welcomes readers’ comments on articles published recently in the journal or orthopedic topics of interest.
- Editorial is invited by the editors and should be commentaries on articles published recently in the journal. Editorial topics could include active areas of research, fresh insights, and debates in the field of orthopedic surgery. Editorials should not exceed 1,000 words, excluding references, tables, and figures.
- Concise Review is short version of systemic review requested to submit in the journal by the Editorial board. Usually, previous papers regarding such topic were published by the main author(s).
- Special Reports/Expert Opinions (Level V studies) of various topics in shoulder and elbow can be submitted. They are limited to 2,700 words excluding references, tables, and figures.

## Title Page

- The title page must include a title, the authors’ names and academic degrees (include ORCID\*), affiliations, and corresponding authors’ names and contact information. In addition, a running title must be written in English within up to 50 characters including spaces. The corresponding authors’ contact information must include a name, addresses, e-mails, telephone numbers, and fax numbers.
- **ORCID:** We recommend that the open researcher and contributor ID (ORCID) of all authors be provided. To have an ORCID,

authors should register in the ORCID website: <http://orcid.org/>. Registration is free to every researcher in the world.

- If there are more than two authors, a comma must be placed between their names (with academic titles). Authors' academic titles must be indicated after their names.
- The contributions of all authors must be described using the CRediT (<https://www.casrai.org/credit.html>) Taxonomy of author roles. All persons who have made substantial contributions, but who have not met the criteria for authorship, are acknowledged here.
- All sources of funding applicable to the study should be stated here explicitly.

### Abstract and Keywords

Each paper should start with an abstract not exceeding 250 words. The abstract should state the background, methods, results, and conclusions in each paragraph in a brief and coherent manner. Relevant numerical data should be included. Under the abstract, keywords should be inserted (maximum 5 words). Authors are recommended to use the MeSH database to find Medical Subject Heading Terms at <http://www.nlm.nih.gov/mesh/meshhome.html>. The abstract should be structured into the following sections.

- **Background:** The rationale, importance, or objective of the study should be described briefly and concisely in one to two sentences. The objective should be consistent with that stated in the Introduction.
- **Methods:** The procedures conducted to achieve the study objective should be described in detail, together with relevant details concerning how data were obtained and analyzed and how research bias was adjusted.
- **Results:** The most important study results and analysis should be presented in a logical manner with specific experimental data.
- **Conclusions:** The conclusions derived from the results should be described in one to two sentences, and must match the study objective.

### Guidelines for the Main Body

- All articles using clinical samples or data and those involving animals must include information on the IRB/IACUC approval or waiver and informed consent. An example is shown below. "We conducted this study in compliance with the principles of the Declaration of Helsinki. The study's protocol was reviewed and approved by the Institutional Review Board of OO (IRB no. OO). Written informed consent was obtained / Informed consent was waived."
- **Description of participants:** Ensure the correct use of the terms "sex" (when reporting biological factors) and "gender" (identity,

psychosocial, or cultural factors), and, unless inappropriate, report the sex and/or gender of study participants, the sex of animals or cells, and describe the methods used to determine sex and gender. If the study was done involving an exclusive population, for example, in only one sex, authors should justify why, except in obvious cases (e.g., ovarian cancer). Authors should define how they determined race or ethnicity and justify their relevance.

- **Introduction:** State the background or problem that led to the initiation of the study. Introduction is not a book review, rather it is best when the authors bring out controversies which create interest. Lead systematically to the hypothesis of the study, and finally, to a restatement of the study objective, which should match that in the Abstract. Do not include conclusions in the Introduction.
- **Methods:** Describe the study design (prospective or retrospective, inclusion and exclusion criteria, duration of the study) and the study population (demographics, length of follow-up). Explanations of the experimental methods should be concise, but yet enable replication by a qualified investigator.
- **Results:** This section should include detailed reports on the data obtained during the study. All data in the text must be presented in a consistent manner throughout the manuscript. All issues which the authors brought up in the method section need to be in result section. Also it is preferred that data to be in figures or table rather than long list of numbers. Instead, numbers should be in tables or figures with key comment on the findings.
- **Discussion:** The first paragraph of the discussion should deal with the key point in this study. Do not start by article review or general comment on the study topic. In the Discussion, data should be interpreted to demonstrate whether they affirm or refute the original hypothesis. Discuss elements related to the purpose of the study and present the rationales that support the conclusion drawn by referring to relevant literature. Discussion needs some comparison of similar papers published previously, and discuss why your study is different or similar from those papers. Care should be taken to avoid information obtained from books, historical facts, and irrelevant information. A discussion of study weaknesses and limitations should be included in the last paragraph of the discussion. Lastly you must briefly state your new (or verified) view of the problem you outlined in the Introduction.
- **References** must be numbered with superscripts according to their quotation order. When more than two quotations of the same authors are indicated in the main body, a comma must be placed between a discontinuous set of numbers, whereas a dash must be placed between the first and last numerals of a contin-

uous set of numbers: “Kim et al. [2,8,9] insisted...” and “However, Park et al. [11–14] showed opposing research results.”

- Figures and tables used in the main body must be indicated as “Fig.” and “Table.” For example, “Magnetic resonance imaging of the brain revealed... (Figs. 1–3).

### Figures and Figure Legends

Figures should be cited in the text and are numbered using Arabic numbers in the order of their citation (e.g., Fig. 1). Figures are not embedded within the text. Each figure should be submitted as an individual file. Location of figure legends begins at the next page after last table. Every figure has its own legend. Abbreviation and additional information for any clarification should be described within each figure legend. Figure files are submitted in EPS, TIFF, or PDF formats. Requirement for minimum resolutions are dependent on figure types. For line drawings, 1,200 dpi are required. For grey color works (i.e., picture of gel or blots), 600 dpi are required. For color or half-tone artworks, 300 dpi are required. The files are named by the figure number.

- Staining techniques used should be described. Photomicrographs with no inset scale should have the magnification of the print in the legend.
- Papers containing unclear photographic prints may be rejected.
- Remove any writing that could identify a patient.
- Any illustrations previously published should be accompanied by the written consent of the copyright holder.

### Tables

- Tables should be numbered sequentially with Arabic numerals in the order in which they are mentioned in the text.
- If an abbreviation is used in a table, it should be defined in a footnote below the table.
- Additional information for any clarification is designated for citation using alphabetical superscripts (<sup>a</sup>, <sup>b</sup>...) or asterisks (\*). Explanation for superscript citation should be done as following examples: <sup>a</sup>)Not tested. \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001.
- Tables should be understandable and self-explanatory, without references to the text.

### References

- The number of references is recommended to 30 for original article and 10 for case report and technical note.
- All references must be cited in the text. The number assigned to the reference citation is according to the first appearance in the manuscript. References in tables or figures are also numbered according to the appearance order. Reference number in the text, tables, and figures should in a bracket ([ ]).

- List names of all authors when six or fewer. When seven or more, list only the first three names and add et al.
- Authors should be listed by surname followed by initials.
- The journals should be abbreviated according to the style used in the list of journals indexed in the NLM Journal Catalog (<http://www.ncbi.nlm.nih.gov/nlmcatalog/journals>).
- The overlapped numerals between the first page and the last page must be omitted (e.g., 2025-6).
- References to unpublished material, such as personal communications and unpublished data, should be noted within the text and not cited in the References. Personal communications and unpublished data must include the individual’s name, location, and date of communication.
- Other types of references not described below should follow IC-MJE Recommendations ([https://www.nlm.nih.gov/bsd/uni-form\\_requirements.html](https://www.nlm.nih.gov/bsd/uni-form_requirements.html)).
- Examples of references are as follows:

#### Journal article

1. Kim IB, Kim EY, Lim KP, Heo KS, Does the use of injectable atelocollagen during arthroscopic rotator cuff repair improve clinical and structural outcomes? *Clin Shoulder Elbow* 2019;22: 183-9.
2. Kovacevic D, Fox AJ, Bedi A, et al. Calcium-phosphate matrix with or without TGF-β3 improves tendon-bone healing after rotator cuff repair. *Am J Sports Med* 2011;39:811-9.
3. Nord KD, Masterson JP, Mauck BM. Superior labrum anterior posterior (SLAP) repair using the Neviaser portal. *Arthroscopy* 2004;20 Suppl 2:129-33.
4. Rohner E, Jacob B, Bohle S, et al. Sodium hypochlorite is more effective than chlorhexidine for eradication of bacterial biofilm of staphylococci and *Pseudomonas aeruginosa*. *Knee Surg Sports Traumatol Arthrosc* 2020 Feb 7 [Epub]. <https://doi.org/10.1007/s00167-020-05887-9>

#### Book & book chapter

5. Iannotti JP, Williams Jr GR. Disorders of the shoulder: diagnosis & management. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007. p. 66-80
6. Provencher MP, LeClere LE, Van Thiel GS, et al. Posterior instability of the shoulder. In: Angelo RL, Esch JC, Ryu RK, eds. AANA advanced arthroscopy the shoulder. Philadelphia, PA: Saunders; 2010. p. 115-23.

#### Website

7. American Cancer Society. Cancer facts & figures 2020 [Internet]. Atlanta, GA: American Cancer Society; c2020 [cited 2020

Feb 5]. Available from: <https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2020.html>.

## 6. FINAL PREPARATION FOR PUBLICATION

### Final Version

After the paper has been accepted for publication, the author(s) should submit the final version of the manuscript. The names and affiliations of the authors should be double-checked, and if the originally submitted image files were of poor resolution, higher resolution image files should be submitted at this time. Symbols (e.g., circles, triangles, squares), letters (e.g., words, abbreviations), and numbers should be large enough to be legible on reduction to the journal's column widths. All symbols must be defined in the figure caption. If references, tables, or figures are moved, added, or deleted during the revision process, renumber them to reflect such changes so that all tables, references, and figures are cited in numeric order.

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Before publication, the manuscript editor will correct the manuscript such that it meets the standard publication format. The author(s) must respond within two days when the manuscript editor contacts the corresponding author for revisions. If the response is delayed, the manuscript's publication may be postponed to the

next issue.

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To correct errors in published articles, the corresponding author should contact the journal's Editorial Office with a detailed description of the proposed correction. Corrections that profoundly affect the interpretation or conclusions of the article will be reviewed by the editors. Corrections will be published as corrigenda (corrections of the author's errors) or errata (corrections of the publisher's errors) in a later issue of the journal.

## 7. ARTICLE PROCESSING CHARGES

There are no author fees required for manuscript processing and/or publishing materials in the journal since all cost is supported by the publisher, the Korean Shoulder and Elbow Society until there is a policy change. Therefore, it is the so-called platinum open access journal.

# Author's checklist

- Manuscript in MS-WORD (.doc) format.
- Double-spaced typing with 10-point font.
- Sequence of title page, abstract and keywords, introduction, methods, results, discussion, conclusions, acknowledgments, references, tables, and figure legends. All pages and manuscript text with line should be numbered sequentially, starting from the abstract.
- Title page with article title, authors' full name(s) and affiliation(s), address for correspondence (including telephone number, e-mail address, and fax number), running title (less than 10 words), and acknowledgments, if any.
- Abstract in structured format up to 250 words for original articles and in unstructured format up to 200 words for case reports. Keywords (up to 5) from the MeSH list of Index Medicus.
- All table and figure numbers are found in the text.
- Figures as separate files, in JPG, GIF, or PPT format.
- References listed in proper format. All references listed in the reference section are cited in the text and vice versa.
- Covering letter signed by the corresponding author.

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**Manuscript Title:**

**Manuscript Number (if applicable):**

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All authors appearing in manuscript should be signed in order.

Each of the undersigned is an author of the manuscript and all authors are named on this document.

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