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Arthroscopic capsular release versus manipulation under anesthesia for primary frozen shoulder

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Diagnosis and treatment of calcific tendinitis of the shoulder
Aims and Scope

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Arthroscopic capsular release (ACR) and manipulation under anesthesia (MUA) are treatment options for primary frozen shoulder (FS). Both of these are useful for primary FS [1-3]. In addition, MUA is possible without the surgical equipment needed for an arthroscopic procedure. The indications for the two procedures are not different, either [1,2].

On this topic, a study by Lee et al. [4], “Can manipulation under anesthesia alone provide clinical outcomes similar to arthroscopic circumferential capsular release in primary frozen shoulder (FS)?: the necessity of arthroscopic capsular release in primary FS” retrospectively reviewed 54 patients treated with MUA and 22 patients treated with ACR. They compared the clinical outcome of both groups with one year follow up after the procedures, and reported that the outcome variables at 3 months after surgery and the improvement of outcome variables did not show any difference between both groups, but in the evaluation of pain and range of motion at 1 week, the MUA group showed significantly better results than the ACR group. They concluded that MUA alone can provide a similar clinical outcome as ACR in refractory FS.

Although MUA is an useful option for primary FS, several complications such as proximal humerus fracture, shoulder dislocation, brachial plexus stretching injury, rotator cuff injury, and glenoid fracture may result [1-3,5]. Therefore, MUA should be performed with great caution. They reported that 11 patients (12.2% in the MUA group and 18.2% in the ACR group) needed additional steroid injection between 8 to 16 weeks after surgery, and the necessity of additional injections was three times higher in diabetics compared to nondiabetics. Previous studies have reported that intraarticular steroid injection is a useful treatment option for primary FS in out-patient department [6-8]. However, additional steroid injection within the follow-up period could be a bias that compromises the reliability of this study.

In addition, a retrospective comparative study by Lee et al. [4] compared patients treated with MUA to patients treated with ACR that followed a limited MUA. The preceding limited MUA could be a source of bias, also. Therefore, the results of this study should be interpreted with caution. Another comparative study reported greater gain in range of motion in a MUA group compared to an ACR group [1]. According to a systemic review of 22 studies, which included 989 patients, there were minimal differences in shoulder range of motion or Constant score between MUA and ACR groups for treatment of refractory FS, and it concluded the data available demonstrate little benefit for ACR instead of, or in addition to, MUA [2]. Well-designed comparative studies are needed.

In my opinion, MUA and ACR are good treatment options for primary FS. MUA is more simple and easy than ACR because ar-
throscopic equipment is not necessary. However, MUA can lead to several serious complications [1-3,5]. If experienced surgeons perform ACR, it can be more safe than MUA. Moreover, ACR is convenient for patients with rotator cuff tears combined with secondary FS [9]. Also, ACR followed by MUA could be better than MUA followed by ACR to avoid the mentioned complications seen with MUA.

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INTRODUCTION

Even if the natural course of primary frozen shoulder (FS) is mostly self-limiting, some patients experience prolonged disability with considerable pain and disability that affect activities of daily life [1,2]. Moreover, some patients fail to achieve desired outcomes with non-operative management. Given the natural history of adhesive capsulitis and the high proportion of patients who do well with nonsurgical management, a trial of at least 6 months of nonsurgical management is normally recommended.

Background: We evaluated the need for arthroscopic capsular release (ACR) in refractory primary frozen shoulder (FS) by comparing clinical outcomes of patients treated with ACR and manipulation under anesthesia (MUA).

Methods: We assessed patients with refractory primary FS, 57 patients (group A) who were treated with MUA and 22 patients (group B) who were treated with ACR. In group A, manipulation including a backside arm-curl maneuver was performed under interscalene brachial block. In group B, manipulation was performed only to release the inferior capsule before arthroscopic circumferential capsular release, which was carried out for the unreleased capsule after manipulation. Pain, range of shoulder motion, and American Shoulder and Elbow Surgeons score were recorded at 1 week, 3 months, 6 months, and 1 year after surgery. We compared outcome variables between treatment groups and between diabetics and non-diabetics and also evaluated the numbers of patients receiving additional intra-articular steroid injection.

Results: Outcome variables at 3 months after surgery and improvements in outcome variables did not differ between groups. Group A showed significantly better results than group B in the evaluation of pain and range of motion at 1 week. Diabetics showed comparable outcomes to non-diabetics for most variables. Eleven patients required additional steroid injections between 8 to 16 weeks after surgery: 12.2% in group A, 18.2% in group B. Additional injections were given three times more often in diabetics compared to non-diabetics.

Conclusions: MUA alone can yield similar clinical outcomes to ACR in refractory FS.

Keywords: Frozen shoulder; Manipulation; Capsular release; Diabetes
before considering surgical management options: manipulation under anesthesia (MUA), arthroscopic capsular release (ACR), or the combination of both [3].

Although ACR is gaining in popularity with recent advances in arthroscopic technique and has shown promising results comparable to those of other treatment modalities [4-6], MUA is a traditionally well-established treatment for FS that is nevertheless controversial due to potential complications (e.g., proximal humerus fractures, shoulder dislocation, brachial plexus stretching injury, rotator cuff injury, and recurrent stiffness) [7-10]. There are no good quality randomized controlled trials in favor of ACR in comparison to MUA [11]; in two previous studies, the superior treatment was not identified [11,12] and manipulation was performed under general anesthesia. Manipulation for FS is usually performed under general anesthesia, but is also performed under interscalene brachial plexus block (ISB) anesthesia and obtains favorable outcomes [13-16].

No previous studies have compared the clinical outcomes of manipulation under ISB anesthesia and ACR. We evaluated differences in clinical outcomes between manipulation under ISB and ACR in refractory primary FS to determine whether ACR is necessary if manipulation under interscalene brachial plexus anesthesia is performed following our novel method. We hypothesized that MUA alone would provide similar clinical outcomes as ACR in primary FS.

**METHODS**

**Study Design and Participants**

We performed a retrospective analysis of a prospectively collected, single surgeon (YSH), single institution, consecutive series of patients with FS. The protocol of this study was reviewed and approved by Institutional Review Board of Kangdong Sacred Heart Hospital (IRB No. 2019-09-016). Written informed consents were obtained. From March 2015 to Mar 2018, 79 patients who were diagnosed with primary FS in our hospital were treated with MUA or ACR. The definition of FS in this study followed the American Shoulder and Elbow Surgeons (ASES) consensus study by Zuckerman and Rokito [17] and was characterized by functional restriction of both active and passive shoulder motion for which radiographs of the glenohumeral joint were essentially unremarkable except for the possible presence of osteopenia. In all patients, shoulder magnetic resonance imaging was used to screen for the coexistence of any other shoulder lesions before indicated management was performed. Patients with rotator cuff tear, shoulder osteoarthritis, calcified tendinitis, hemiplegia after stroke, bone metastasis in the shoulder region, history of shoulder fractures, and history of shoulder surgeries were excluded. Diabetic FS patients were not excluded because while diabetes is a possible predisposing factor based on statistical data, it is not known to be a cause of FS [18]. Refractory FS was defined as follows: refractory to conservative treatment (intra-articular steroid injections and physical therapy) for at least 6 months and documented restriction of both passive and active glenohumeral and scapulothoracic motion of equal to or less than 100° of elevation, and less than 50% of external rotation, as compared to the contralateral side [11].

Both treatment modalities were indicated by refractory FS. There were no differences in indications between the two modalities. ACR after MUA was used from January 2015 to May 2017, and the two modalities were used randomly without special indications for either during the 5 months from January 2017 onward. After this period of overlap, we recognized that the two modalities showed similar clinical outcomes. MUA alone was used after May 2017 to facilitate comparisons of the modalities. All 79 patients treated during this period who were followed closely over 6 months after treatments were reviewed. A total of 57 patients (group A) were treated with MUA and 22 patients (group B) were treated with ACR after manipulation. We evaluated range of motion (ROM; passive forward elevation, external rotation arm at side, and thumb reach along the vertebral spine, in which the thumb points up), visual analog pain score, and ASES score preoperatively and at 1 week, 3 months, 6 months, and 1 year after surgery. All outcome variables in this study were measured by trained residents and physician assistants under the supervision of the senior author (YSH). We consider the number of vertebral spines in which the patient’s thumb can reach up, which we refer to as thumb-to-spine, to be better than degree of internal rotation for the evaluation of surgical outcomes. When the patient’s thumb reaches up over the thoracolumbar junction, we defined it as a pass. Regarding the evaluation of pain severity, we asked the patient for an average value, taking into account pain while sleeping at night, pain while resting, and pain during everyday activities. We compared results for the two groups and analyzed them statistically. We compared outcome measurements, pretreatment period, follow-up period, and number of additional intra-articular steroid injections between groups. We also compared all variables between diabetic and non-diabetic patients.

**Study Procedures**

In group A, all MUA procedures were performed by a single surgeon (YSH) following a standardized, identical protocol. MUA was performed in outpatient settings. The patient was made to lie
down in a supine position after interscalene plexus block was performed by the anesthesiologist. Before MUA, intra-articular steroid injections were performed to control post-MUA inflammation and pain (triamcinolone 40 mg, 1 mL+lidocaine 0.1%, 5 mL+sterile normal saline, 4 mL). Manipulations were first performed at forward flexion with scapular stabilization by an assistant, and then at external rotation with the arm at the side, and finally at 90° abduction (Fig. 1) [16]. Next, internal rotation was performed with the arm at 90° abduction, while the assistant pushed the shoulder girdle downward to the floor (Fig. 1A) [16]. During 90° abduction with full internal rotation, further abduction can lead to further capsular release indicated by an audible sound (Fig. 1B). Next, horizontal adduction with scapular stabilization was performed. After the patient was made to sit, we placed the patient's hand behind their back and then pushed the patient's arm backwards, while pushing the patient's hand up with forced adduction (Fig. 2). This last step is the “backside arm-curl maneuver.” Most of the time, a recognizable tearing sound was heard during each step. The sequence was repeated until the maximum ROM was acquired. A short lever arm with the elbow flexed at 90° is used to prevent fractures and brachial plexus traction injuries. After MUA completion, the recovered range of shoulder motion was confirmed with the patient (Fig. 3). The patient was instructed to start passive exercise programs immediately after MUA to maintain the restored ROM, in which forward elevation and the backside arm-curl maneuver were emphasized (Fig. 4). The patient was also instructed to perform a self-assisted stretch for 5 minutes every hour until the next visit. Patients were allowed to go home after recovery from ISB anesthesia.

In group B, manipulation preceded arthroscopic procedures and was performed at forward elevation only for the safe release of the inferior capsular area after interscalene plexus block and

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**Fig. 1.** (A) Internal rotation with the arm at 90° abduction, with the assistant pushing the shoulder girdle downward toward the floor was performed to complete the posterior and inferior capsule tear. (B) With 90° abduction with full internal rotation, further abduction can result in further capsular release with an audible sound.

**Fig. 2.** Backside arm-curl maneuver. (A) It is often hard to place the patient's hand on the midline of the back in the sitting position even after full restoration of internal rotation in the supine position. (B, C) After the patient was made to sit, we placed the patient's hand behind their back and then pushed the patient's arm backwards, while pushing the patient's hand up with forced arm adduction.
general anesthesia. Therefore, the backside arm-curl maneuver in the sitting position was omitted in group B. During ACR, the unreleased inferior capsule, anterior capsule, posterior capsule, and anterior part of the superior capsule (superior glenohumeral ligament and coracohumeral ligament) were released. After arthroscopic 360° circumferential capsular release, an epidural catheter was inserted into the glenohumeral joint space for intra-articular steroid injection. The day after surgery, the passive exercise program was started after intra-articular steroid injection. The exercise program in group B also emphasized forward elevation and the backside arm curl maneuver. The patients remained in hospital until they showed more than 135° of forward elevation and could reach higher than the fifth lumbar vertebra during the backside arm curl maneuver at least once. The length of hospital stay after surgery averaged 1 or 2 days. We informed the patient that the sooner they began exercise the better regarding the result of ROM restoration. The patient was also instructed to perform a self-assisted stretch for 5 minutes every hour until the next visit. All patients received instructions to perform rehabilitation on their own without help.

Within 1 week after discharge, all patients in both groups visited the outpatient clinic to check whether they had maintained the restored ROM in group A and how much ROM had been restored in group B. All patients were evaluated according to our follow-up schedule. In group B, additional visits during the month after surgery were performed to encourage patients to perform rehabilitation exercises because most group B patients did not show significant improvements in pain and ROM at the first visit. During the follow-up period, we performed intra-articular steroid injections (triamcinolone 40 mg, 1 mL + lidocaine 0.1%, 5 mL + sterile normal saline, 4 mL) if the patient complained of aggravated pain impeding ROM exercises and night sleep.

For statistical analysis, independent t-tests (age), Fisher’s exact tests (sex) and Mann-Whitney U-tests (ASES scores, ROM, pretreatment periods, follow-up periods, pain VAS) were used with significance set at the 5% level (IBM SPSS 22.0; IBM Corp., Armonk, NY, USA).

RESULTS

There were no significant differences in demographic data between groups (Table 1). Twenty-four patients had diabetes mellitus (30.4%, 24 of 79 patients). Three patients had thyroid disease in group A, while none did in group B. Preoperative outcome

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A</th>
<th>Group B</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>57</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>55.3 ± 8.5</td>
<td>53.9 ± 6.4</td>
<td>0.474</td>
</tr>
<tr>
<td>Male:female</td>
<td>24:33</td>
<td>8:14</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>17 (29)</td>
<td>7 (32)</td>
<td>0.443</td>
</tr>
<tr>
<td>Thyroid disease case</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pretreatment period (mo)</td>
<td>6.4 ± 3.7</td>
<td>6.6 ± 4.1</td>
<td>0.391</td>
</tr>
<tr>
<td>Follow-up period (mo)</td>
<td>7.68 ± 1.7</td>
<td>7.22 ± 1.6</td>
<td>0.285</td>
</tr>
</tbody>
</table>

Values are presented as mean ± standard deviation or number (%).
variables, outcome variables at 3 months after surgery, and amount of improvement in all variables (ASES score, pain VAS, and ROM) did not differ between groups (Tables 1 and 2). However, at the last visit, the degree of forward elevation was better in group A than group B (p = 0.029) although other outcome variables did not differ between groups.

No patients were able to raise their thumbs higher than the thoracolumbar junction. At the first visit after surgery, all patients in group A were graded as passing. In later evaluations, all patients in group A continued to be graded as passing. However, in the ACR group, only five patients passed at their first visit. The numbers of patients who passed were 12 at 1 month, 21 at 3 months, and 22 (all patients) at the last visit. Group A showed significantly better results than group B for pain and ROM (Table 1).

No patients in either group (manipulation under ISB only and ACR with MUA) showed decreased ROM during the follow-up period. Seven patients among 57 treated by MUA (12.2%) and four by ACR (18.2%) complained of aggravated pain between 8 and 16 weeks (median value, 10 weeks) after surgery. The pain in these 11 patients subsided after a single intra-articular steroid injection and did not recur during the follow-up period. These 11 patients did not show any significant differences in ROM, ASES score, or severity of pain at final evaluation. No serious complications after manipulation, such as shoulder dislocation, rotator cuff tear, or brachial plexus palsy were reported in our patients.

We included 24 diabetic patients (30.4%, 24/79) in this study. When outcome variables were evaluated without grouping, diabetic patients showed slightly worse outcomes at 3 months after surgery, but no significant little differences in last values or improvement of outcome variables (Table 3). The results were different when each group was analyzed separately. There were no differences in clinical outcomes between diabetics and non-diabetics in group A (Table 3). In group B, diabetics had worse outcomes at 3 months after surgery and at the last visit, but there were no differences in improvement of ASES score or ROM except for pain severity (Table 3). Among patients who needed additional intra-articular steroid injections, 41.2% of diabetic patients (7/17) and 7.5% of non-diabetic patients (1/13) in group A needed additional injections, and 57.1% of diabetic patients (4/7) and 11.1% of non-diabetic patients (2/18) in group B needed additional injections.

**DISCUSSION**

We did not detect differences in overall outcomes between patients treated with MUA and ACR. Interestingly, pain severity and ROM scores were better in the MUA group than the ACR group.

### Table 2. Outcome variables in groups A and B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative</th>
<th>First visit within 1 week</th>
<th>After 3 months</th>
<th>Last visit</th>
<th>Improvement</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain VAS</td>
<td>56.3±12.3</td>
<td>56.3±12.3</td>
<td>58.6±13.5</td>
<td>59.2±12.3</td>
<td>&lt;0.001</td>
<td>0.547</td>
</tr>
<tr>
<td>ASES score</td>
<td>48.7±8.2</td>
<td>48.7±8.2</td>
<td>48.3±6.4</td>
<td>48.3±6.4</td>
<td>&lt;0.001</td>
<td>0.403</td>
</tr>
<tr>
<td>Range of motion</td>
<td>87.5±9.7</td>
<td>87.5±9.7</td>
<td>84.5±6.9</td>
<td>84.5±6.9</td>
<td>&lt;0.001</td>
<td>0.533</td>
</tr>
<tr>
<td>FE</td>
<td>6.3±7.4</td>
<td>6.3±7.4</td>
<td>6.1±5.0</td>
<td>6.1±5.0</td>
<td>&lt;0.001</td>
<td>0.403</td>
</tr>
<tr>
<td>ERside</td>
<td>57.5±10.5</td>
<td>57.5±10.5</td>
<td>57.5±10.5</td>
<td>57.5±10.5</td>
<td>&lt;0.001</td>
<td>0.403</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation. VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons, FE: forward elevation, ERside: external rotation arm at side. The ratio of the number of patients whose thumb could reach up over the thoracolumbar junction, group A: group B.

https://doi.org/10.5397/cise.2020.00283
Table 3. Outcome variables in diabetic patients and non-diabetic patients among all 79 patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative</th>
<th>After 3 months</th>
<th>Last visit</th>
<th>Improvement*</th>
<th>Preoperative</th>
<th>After 3 months</th>
<th>Last visit</th>
<th>Improvement*</th>
<th>Preoperative</th>
<th>After 3 months</th>
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<td>DM</td>
<td>p-value</td>
</tr>
<tr>
<td>Pen</td>
<td>17.5 ± 10.7</td>
<td>77.1 ± 23.8</td>
<td>57.4 ± 14.3</td>
<td>47.5 ± 10.2</td>
<td>76 ± 14.3</td>
<td>47.5 ± 10.2</td>
<td>54.6 ± 13.7</td>
<td>47.5 ± 10.2</td>
<td>86 ± 14.3</td>
<td>47.5 ± 10.2</td>
<td>54.6 ± 13.7</td>
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<td>VAS</td>
<td>8.9 ± 3.1</td>
<td>32.7 ± 9.2</td>
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<td>32.7 ± 9.2</td>
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<td>32.7 ± 9.2</td>
<td>32.7 ± 9.2</td>
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</tr>
<tr>
<td>ASES score</td>
<td>87.1 ± 12.4</td>
<td>87.1 ± 12.4</td>
<td>87.1 ± 12.4</td>
<td>87.1 ± 12.4</td>
<td>87.1 ± 12.4</td>
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<tr>
<td>Range of motion</td>
<td>57.5 ± 12.4</td>
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Values are presented as mean±standard deviation.


*The amount of improvement of outcome variables between preoperative values and values at the last visit; improvement=value at last visit−preoperative value.

However, no previous studies have compared outcomes of diabetes and the natural history of adhesive capsulitis and the high proportion of patients who do well with nonsurgical management is generally recommended before considering surgical management in diabetic patients requiring additional injections was three times higher than non-diabetic patients. Given the natural history of adhesive capsulitis and the high proportion of patients who do well with nonsurgical management is generally recommended before considering surgical management options [3], MUA and ACR are the two most common surgical management strategies. There are no good quality randomized controlled trials with findings showing the superiority of ACR compared to MUA [11] but ACR is favored over MUA because it is believed to allow more control and complete release of the contracted capsule to reduce the risk of iatrogenic injury compared to MUA and also resulted in favorable short-term and long-term outcomes [11-19]. In our study, patients treated with MUA showed improved ROM, whereas others have determined that partial capsular release (anteroinferior capsular release) is sufficient [12,24,25].

Recent developments in ultrasound technology have enabled its use with brachial plexus anesthesia or cervical root block [13]. Some authors have recommended 360º capsular release to restore normal ROM, whereas others have determined that partial capsular release (anteroinferior capsular release) is sufficient [12,24,25]. There is controversy regarding the optimal method of ACR. There are no good quality randomized controlled trials with findings showing the superiority of ACR compared to MUA [11] but ACR is favored over MUA because it is believed to allow more control and complete release of the contracted capsule to reduce the risk of iatrogenic injury compared to MUA and also resulted in favorable short-term and long-term outcomes [11-19]. In our study, patients treated with MUA showed improved ROM, whereas others have determined that partial capsular release (anteroinferior capsular release) is sufficient [12,24,25]. There is controversy regarding the optimal method of ACR. There are no good quality randomized controlled trials with findings showing the superiority of ACR compared to MUA [11] but ACR is favored over MUA because it is believed to allow more control and complete release of the contracted capsule to reduce the risk of iatrogenic injury compared to MUA and also resulted in favorable short-term and long-term outcomes [11-19]. In our study, patients treated with MUA showed improved ROM, whereas others have determined that partial capsular release (anteroinferior capsular release) is sufficient [12,24,25]. There is controversy regarding the optimal method of ACR. There are no good quality randomized controlled trials with findings showing the superiority of ACR compared to MUA [11] but ACR is favored over MUA because it is believed to allow more control and complete release of the contracted capsule to reduce the risk of iatrogenic injury compared to MUA and also resulted in favorable short-term and long-term outcomes [11-19].
Our study may be the first to compare the outcomes of patients treated by both modalities in a single institution. Our novel manipulation techniques resulted in comparable clinical outcomes to ACR.

Only two previous studies compared outcomes of MUA and ACR in patients with refractory FS [11,12]. Neither determined which of the two treatment modalities is superior. Grant et al. [11] conducted a systematic review and concluded that given the low level of evidence and lack of direct comparisons, there are no clear differences in shoulder ROM or patient-reported outcomes when comparing MUA to ACR for the treatment of refractory primary FS. Kim et al. also reported similar results, that MUA (general anesthesia) offered equivalent clinical outcomes compared with ACR (360º circumferential release) in the early period after the procedure [12]. However, they recommended that clinicians should consider MUA as an option before choosing ACR in patients with refractory FS because MUA is simple, safe, and cost-effective.

In this study, we introduced and described the novel backside arm-curl maneuver in the sitting position. In previous studies of MUA in primary FS, the descriptions of manipulation procedures are brief or variable, and procedures are generally not conducted in the sitting position [12,15,18,20,25]. For the successful restoration of ROM in MUA, the restoration of the height of thumb reach up the spine as well as forward elevation is very important. We found that sufficient shoulder extension, backward elevation, and adduction in the sitting position are critical for the restoration of the height of the thumb reaching up the spine to normal range and tearing sounds are audible during this procedure. Performance of the backside arm-curl maneuver in the sitting position is extremely important.

Woods and Loganathan [30] found that patients with successful outcomes have significant improvement in pain within three to four days after MUA, and improvement in ROM within about three weeks. Kraal et al. [29] also found that an initial period of one to 2 weeks of intensive physiotherapy after MUA is essential to prevent recurrence of restrictions and advocated more aggressive rehabilitation with intensive stretching and ROM exercises in the first weeks after MUA to preserve the obtained ROM. The importance of early rehabilitation is the same in ACR and MUA in terms of surgical treatment for joint stiffness [20]. We also emphasized the early restoration of ROM in both groups. Patients in the MUA-only group showed earlier improvements in pain and ROM at first visit than the ACR group, although there was no significant difference at 3 months between groups. Final outcomes are important, but it is also important to treat pain quickly and restore ROM. The faster recovery of ROM and pain, the better the patient's treatment compliance.

When using our method of performing MUA, we were able to immediately confirm ROM recovery during manipulation under ISB. ISB and intra-articular steroid injections minimized pain during the rehabilitation exercise, which was carried out immediately after MUA, so ROM restored with the procedure was well maintained. Immediate initiation of exercise after manipulation for 6 to 8 hours becomes possible thanks to the use of ISB, and intra-articular steroid injections also reduce pain on exercise after ISB wears off. Less invasive procedures than ACR are also helpful to reduce pain on rehabilitation. Patients in the ACR group reported more pain during joint exercise compared to MUA at their first outpatient visits.

There are clear differences difference between presence and absence of restored ROM. In manipulation under ISB, there is no ROM to restore, and full restoration is accomplished as soon as manipulation is complete. In MUA or ACR under general anesthesia, the immediate confirmation of restoration of ROM with the patient is difficult or impossible, and some patients doubt the success of manipulation if rehabilitation is onerous or they do not restore normal ROM.

Regarding the recurrence of FS after MUA, two previous studies of MUA reported rates of recurrence of between 10% and 40% [30,31]. Woods and Loganathan [30] performed further MUA if there were no improvements in ROM or pain 3 months after MUA. They also reported a period of recurrence in some patients (17.8%, 141 of 792 shoulders) between 6 and 8 weeks after treatment, which could be accounted for by the loss of the effect of the intra-articular steroid injection. In our study, no patients experienced decreased ROM during the follow-up period, while 11 patients complained of aggravated pain between 8 and 16 weeks after the procedure: seven of 57 patients (12.2%) in the MUA group and four of 22 patients (18.2%) in the ACR group.

FS is strongly associated with diabetes and is two to four times more common in diabetic patients than in the general population [32-36]. FS in patients with diabetes tends to have a more severe and protracted course, and to be difficult to treat [32,37,38]. Some researchers have suggested that patients with diabetes should consider ACR, but most of our patients experienced good outcomes after manipulation alone [17]. However, in our study, diabetic patients showed slightly worse outcomes compared with non-diabetic patients although outcome variables in the ACR group were not significantly different. We observed no differences in any outcome variables in the MUA group, a finding that is consistent with those of other reports and suggests that diabetes is not a contraindication for MUA [16,18,31,34]. Regarding recurrence after surgery, Jenkins et al. reported that re-
peat MUA was required in 36% of diabetic patients compared with 15% of nondiabetic patients, and Woods and Loganathan [30] reported that patients with type-1 diabetes mellitus were at 38% increased risk of requiring further MUA, compared with 18% increased risk among a group that included both diabetics and non-diabetic patients [31]. Regarding recurrence pain, diabetic patients were more than three times as likely to experience recurrence than non-diabetics (41.2% vs. 7.5% in group A and 57.1% vs. 11.1% in group B) in our study.

This study has several limitations. It is a retrospective, non-randomized study with a relatively small sample size. Sample sizes are also different between groups. There may be subtle differences in the indications of the two procedures because ACR requires general anesthesia, so it can be more difficult for patients to accept than MUA, which is performed under regional anesthesia. We developed and introduced the backside arm-curl maneuver with good success, but further research is needed to validate this procedure. Future studies should include evaluations of ROM improvement after manipulation with and without the backside arm-curl maneuver. Comparisons between manipulation under ISB and general anesthesia should also be performed in the future. Despite these limitations, our study is the first to compare the clinical results of manipulation under ISB with ACR.

In primary FS, manipulation under ISB alone can result in similar and favorable clinical outcomes with ACR in refractory cases. Regardless of type of surgery, clinical outcomes in patients with diabetes were similar to those without diabetes. However, diabetic patients often require additional intra-articular steroid injections.

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**REFERENCES**

Peri-anchor cyst formation after arthroscopic bankart repair: comparison between biocomposite suture anchor and all-suture anchor

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Background: The purpose of this study is to investigate clinical outcomes and radiological findings of cyst formation in the glenoid around suture anchors after arthroscopic Bankart repair with either biocomposite suture anchor or all-suture anchor in traumatic anterior shoulder instability. We hypothesized that there would be no significant difference in clinical and radiological outcomes between the two suture materials.

Methods: This retrospective study reviewed 162 patients (69 in group A, biocomposite anchor; 93 in group B, all-suture anchor) who underwent arthroscopic Bankart repair of traumatic recurrent anterior shoulder instability with less than 20% glenoid defect on preoperative en-face view three-dimensional computed tomography. Patient assignment was not randomized.

Results: At final follow-up, the mean subjective shoulder value, Rowe score, and University of California, Los Angeles shoulder score improved significantly in both groups. However, there were no significant differences in functional shoulder scores and recurrence rate (6%, 4/69 in group A; 5%, 5/93 in group B) between the two groups. On follow-up magnetic resonance arthrography/computed tomography arthrography, the incidence of peri-anchor cyst formation was 5.7% (4/69) in group A and 3.2% (3/93) in group B, which was not a significant difference.

Conclusions: Considering the low incidence of peri-anchor cyst formation in the glenoid after Bankart repair with one of two anchor systems and the lack of association with recurrence instability, biocomposite and all-suture anchors in Bankart repair yield satisfactory outcomes with no significant difference.

Keywords: Shoulder; Joint instability; Arthroscopic surgery; Suture anchor; Cyst

INTRODUCTION

The shoulder is a commonly dislocated joint in the human body. In young patients, recurrence of shoulder instability can occur in up to 90% with some surgical options [1-3]. With the advent and development of suture anchors, arthroscopic Bankart repair has replaced open Bankart repair with a classic transosseous technique. Furthermore, suture anchor has become one of the most important factors for restoration of recurrent shoulder instability [4,5].
The first generation of suture anchors comprised metallic materials (stainless steel or titanium) and could produce stable fixation and satisfactory clinical outcomes. However, many severe complications were reported, such as loosening, intra-articular migration, and protrusion into the shoulder joint resulting in cartilage injury [6-10]. Thereafter, non-metallic second-generation (bioabsorbable and biocomposite) suture anchors were introduced to overcome these complications and are widely used in the arthroscopic field [6,10,11]. Nonetheless, there have been issues related with rapid degradation leading to intraosseous cyst formation and osteolysis [10,12]. Recently, a third generation of suture anchors (all-suture type) was introduced. These all-suture anchors avoid osteolysis due to degradation or cartilage injury caused by a loose body. However, a recent study raised the concern that the all-suture-type anchor created a cyst-like cavity in vivo and resulted in inferior biomechanical properties except ultimate failure load compared to biocomposite suture anchor [13].

The purpose of this study is to investigate clinical outcomes and radiological findings regarding cyst formation in the glenoid around suture anchors after arthroscopic Bankart repair with either biocomposite suture anchor or all-suture anchor in traumatic anterior shoulder instability. We hypothesized that there would be no significant difference in clinical and radiological outcomes between the two suture materials.

METHODS

Study Population
This retrospective study reviewed 211 patients who underwent arthroscopic Bankart repair of traumatic recurrent anterior shoulder instability using either biocomposite suture anchor (Su-tureTak, Arthrex, Naples, FL, USA; group A) or all-suture anchor (Y-Knot Flex, ConMed Linvatec, Largo, FL, USA; group B) performed by a senior author from January 2011 to February 2017. Patient assignment was not randomized. The indications of surgery were discomfort in activities of daily-living and positive apprehension test.

The inclusion criteria were Bankart lesion with less than 20% glenoid defect on preoperative en-face three-dimensional (3D) computed tomography (CT) and (2) available for a minimum 2-year follow-up after surgery. The exclusion criteria were (1) previous operative history on affected shoulder, (2) revision surgery, (3) unavailability for at least 2 years of follow-up, (4) concomitant rotator cuff repair, (5) combined posterior or multi-directional instability, and (6) lack of follow up magnetic resonance arthrography (MRA) or computed tomography arthrography (CTA) after 6 months postoperatively. Finally, 162 patients (69 in group A, biocomposite anchor; 93 in group B, all-suture anchor) who satisfied the inclusion and exclusion criteria and their medical records and radiologic data were reviewed retrospectively. This study was approved by the Institutional Review Board of Severance Hospital, Yonsei University College of Medicine, with waiver of the requirement for patient-informed consent.

Functional and Radiologic Assessments
Functional assessments were performed using the following indices: subjective shoulder value (SSV; the percentage value of the affected shoulder compared to that of the normal shoulder), Rowe score, University of California, Los Angeles (UCLA) shoulder score, and shoulder active range of motion (ROM; forward flexion in the scapular plane, external rotation with the elbow at the side and external and internal rotation in 90° of abduction). During each patient visit, an independent examiner evaluated the preoperative and postoperative shoulder functional scores and measured active ROM. We defined recurrence instability as subluxation episode, re-dislocation, or positive apprehension sign at 90° abduction and external rotation of the shoulder. Preoperative radiologic assessments included standing true antero-posterior views of the shoulder in neutral and axillary positions and MRI or MRA studies. Follow-up MRA (3.0-T MR imaging unit, MAGNETOM Tim Trio; Siemens, Erlangen, Germany) or CTA (SOMATOM Sensation 64; Siemens) was performed 6 months after operation.

Surgical Techniques and Postoperative Rehabilitation
All patients underwent arthroscopic Bankart repair in lateral decubitus position under general anesthesia in the setting of longitudinal traction with 10 lbs. A superior viewing portal, low anterior portal for anchor insertion, and posterior portal for shuttle relay were established. Viewed from the superior portal, a Bankart lesion was identified. After sufficient release of detached anteroinferior labrum, the glenoid edge was prepared. The first anchor was inserted at the 5 o’clock of the glenoid rim in the right shoulder (7 o’clock in the left shoulder), and the suture was passed through the capsule. After shuttle-relay, a knot was secured on the capsular side of the labrum. In the same manner, the subsequent two or three anchors were inserted and secured in a row.

After surgery, the shoulder was held in an abduction brace for 4 to 5 weeks. A self-assisted circumduction exercise was initiated the day after surgery. Self-assisted passive ROM exercises were initiated as tolerated after removal of the brace. Self-assisted active ROM exercises were initiated eight weeks after surgery. Isotonic strengthening exercises with an elastic band were encour-
aged 3 months after surgery. The patients were allowed to return to their premorbid level of sports activities 6 months after surgery.

**Statistical Analysis**

Statistical analysis was performed using the IBM SPSS ver. 23.0 (IBM Corp., Armonk, NY, USA). Student t-test was used to compare continuous or continuous ranked data, such as shoulder functional scores (SSV, Rowe, UCLA) and ROM between groups. Paired t-test was used to compare preoperative and postoperative values within each group. The chi-square test was used to compare categorical data such as presence of cyst and recurrence instability. Statistical significance was set at p < 0.05.

**RESULTS**

Patient demographics are summarized in Table 1, and there was no significant difference in any metric between the two groups. At final follow-up, the mean SSV, Rowe score, and UCLA shoulder score improved significantly in both groups: mean SSV improved from 40.1 to 93.2 in group A (p < 0.001) and from 40.9 to 92.8 in group B (p < 0.001); mean Rowe score improved from 46.1 to 91.6 in group A (p < 0.001) and from 47.2 to 90.9 in group B (p < 0.001); mean UCLA shoulder score improved significantly from 22.9 to 32.3 in group A (p < 0.001) and from 23.5 to 32.5 in group B (p < 0.001). There was no significant difference in these functional scores between the two groups (Table 2). During the study period, instability recurred in four patients (6%, 4/69) in group A and five patients (5%, 5/93) in group B, with no significant difference.

On preoperative 3D CT, the mean glenoid defect percentage was 15.6%±3.3% in group A and 14.9%±3.4% in group B. There was no significant difference between the two groups. On follow-up MRA/CTA, the incidence of peri-anchor cyst formation was 5.7% (4/69) in group A and 3.2% (3/93) in group B, with no significant difference.

**DISCUSSION**

The purpose of this study is to investigate clinical outcomes and radiological findings regarding cyst formation in the glenoid around suture anchors after arthroscopic Bankart repair with either biocomposite suture anchor or all-suture anchor in traumatic anterior shoulder instability. As we hypothesized, there was no significant difference in clinical outcomes including recurrence instability and incidence of peri-anchor cyst formation.

The bone reaction around the anchor is a complication after use of bioabsorbable anchors in the shoulder, and peri-anchor reaction has occurred in the glenoid after SLAP or Bankart repair as well as in the humeral head after rotator cuff repair [10,11,14]. Milewski et al. [11] reported bone replacement of biocomposite anchor in labral repair. In their study, 98% of anchor material was absorbed, 78% was replaced by soft tissue of variable density, and 20% was replaced by bone at 24 months after surgery. Three of

<table>
<thead>
<tr>
<th>Table 1. Patient demographics</th>
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<tr>
<td>Variable</td>
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<tr>
<td>Sex (male:female)</td>
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<td>Age (yr)</td>
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<td>Symptom period (mo)</td>
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<tr>
<td>Mean period of follow-up (mo)</td>
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<tr>
<td>Number of suture anchors</td>
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<td>Additional remplissage</td>
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Values are presented as mean±standard deviation (range). Group A, biocomposite anchor; Group B, all suture anchor.

<table>
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<tr>
<th>Table 2. Preoperative and final follow-up shoulder functional scores for both groups</th>
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<tr>
<td>Variable</td>
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<tr>
<td>Preoperative SSV</td>
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<tr>
<td>Final follow-up SSV</td>
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<tr>
<td>Preoperative Rowe score</td>
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<tr>
<td>Final follow-up Rowe score</td>
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<tr>
<td>Preoperative UCLA shoulder score</td>
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<td>Final follow-up UCLA shoulder score</td>
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</table>

Values are presented as mean±standard deviation. Group A, biocomposite anchor; Group B, all suture anchor.

SSV: subjective shoulder value, UCLA: University of California, Los Angeles.
47 anchors (6.3%) showed peri-anchor cyst formation, which was similar to the incidence (7.2%) of the current study. Kim et al. [10] investigated the incidence of osteolysis and cyst formation after use of bioabsorbable anchors in rotator cuff repair. The incidence was 46.4% with variable grades of osteolysis, and they indicated that use of this bioabsorbable anchor should be reconsidered due to interference in revision surgery considering preservation of bone stock in the setting of adequate anchor resorption.

All-suture anchor was introduced in 2010 [15], to eliminate or reduce the concerns of bioabsorbable or biocomposite suture anchors, and recent studies underscored its clinical implications [15-17]. Although all-suture anchors have equivalent ultimate failure load to the traditional solid anchor system [18,19], Pfeiffer et al. [13] revealed in their in vivo study that these all-suture anchor system produced increased tunnel width and greater displacement under cyclic load. Tompane et al. [15] demonstrated that all-suture anchor yielded a low rate of cyst formation, and tunnel expansion greater than 80% was found in most patients at 12-month follow-up. However, this increased tunnel volume was not associated with clinical outcomes and recurrence instability. Lee et al. [16] compared the all-suture anchor with biodegradable anchor in arthroscopic Bankart repair and found that tunnel expansion was significantly greater in the all-suture anchor at 1-year follow-up, although it was not associated with clinical outcomes including recurrence instability during the study period. Similarly, the current study showed no significant difference in cyst formation (5.7% vs. 3.2%) at 6 month follow-up MRA/CTA or in clinical outcomes and recurrence instability.

Nakagawa et al. [20] raised the concern that cystic change and tunnel expansion in the glenoid might increase some unknown risk for anterior glenoid rim, especially in the setting of linear arrangement of multiple all-suture anchors. Although a large number of anchors was not always associated with glenoid rim fracture, they suggested that linear placement of suture anchors might induce weakness of the glenoid fossa and following glenoid rim fracture. Park et al. [21] reported similar cases of anterior glenoid rim fracture after arthroscopic Bankart repair. They used metal or bioabsorbable anchors and indicated that osteolysis around the suture anchor, especially without ceramic composite, might lead to rim fracture. In the current study, there was no glenoid rim fracture after Bankart repair.

There are several limitations to this study. First, this is a non-randomized retrospective study that has inherent selection bias for patient assignment. In the early study period, the biocomposite anchor was used, while the all-suture anchor was used later in the study. Second, the lack of significant difference in clinical outcomes might be due to the low statistical power resulting from the small number of patients. Third, we could not analyze tunnel expansion but only cyst formation because MRA was used in many cases. Fourth, follow-up MRA/CTA was performed 6 months after surgery, which may not be long enough to evaluate peri-anchor cyst formation.

In conclusion, considering the low incidence of peri-anchor cyst formation in the glenoid after Bankart repair with the two anchor systems and the lack of association with recurrence instability, both biocomposite and all-suture anchors in Bankart repair can yield satisfactory outcomes with no significant difference.

**REFERENCES**


https://doi.org/10.5397/cise.2020.00290
INTRODUCTION

Radial head fractures are relatively common in orthopedic injuries, comprising 1.7%–5.4% of all fractures, 33% of those being around the elbow joint [1]. Although radial head fractures are often stable injuries, one-third are associated with another bone or soft tissue injury, including coronoid fracture, ligamentous injuries, or elbow dislocation [2]. The goal of treatment is to restore the structure of the radial head, which functions as an important stabilizer to varus and valgus stress of the elbow [3]. The Mason classification is commonly used for radial head fractures [4]. Type I and II fractures are treated either non-operatively or by...
open reduction and internal fixation (ORIF). Type III and IV fractures are treated by ORIF or radial head replacement (RHR). However, the ideal treatment method continues to be controversial.

Numerous studies have compared the clinical outcomes of ORIF and RHR for Mason type III or IV fractures. Several studies have reported that ORIF achieves more satisfactory results in complex radial head fractures [5,6]. Conversely, some studies have reported that RHR produces superior outcomes compared with ORIF by providing early stability [7,8]. ORIF can result in a malunion or a painful, stiff elbow due to bone resorption and loosening [9,10]. Ring et al. [10] emphasized that fractures with more than three articular fragments had an unsatisfactory result after ORIF. In complex radial head fractures that are considered unreconstructable by ORIF, RHR offers better results than ORIF by achieving effective radiocapitellar contact, which improves the stability of the elbow [11].

RHR is indicated in cases of unreconstructable isolated radial head fractures and complex elbow injuries such as elbow fracture-dislocation, terrible triad injuries, Monteggia fractures, or Essex-Lopresti lesions [2]. Although RHR produces satisfactory outcomes [12,13], several studies have reported that it has a high percentage of complications and a higher risk of requiring reoperation [14-16]. With these distinct benefits and risks, it remains to be determined whether RHR should become the primary treatment for complex radial head fractures. The primary aim of the current study was to investigate short- to mid-term outcomes and complications after RHR for complex radial head fractures. The secondary aim was to identify the factors associated with clinical outcomes following RHR.

**METHODS**

The current study was approved by Institutional Review Board of Keimyung University Dongsan Hospital (IRB No. 2020-11-006). Cases for 29 patients with RHR for complex radial head fractures at a single institution between 2006 and 2018 were retrospectively reviewed. The indications for RHR were complex radial head fractures with associated injuries including ligamentous injuries, terrible triad injuries, Monteggia fractures, or Essex-Lopresti lesions. Inclusion criteria were as follows: (1) RHR for complex radial head fracture, (2) available medical records and radiographic findings, and (3) follow-up period of more than 2 years following surgery. Exclusion criteria were (1) fracture sequelae and (2) failed ORIF. After applying the inclusion and exclusion criteria, 24 patients were included in the current study.

The mean age of the patients was 49.8 years (range, 19–73 years). There were 11 women and 13 men. According to the Mason classification, 12 patients had type III fracture and 12 had type IV fracture. One patient had an open fracture. The mean interval from initial trauma to surgery was 8.7 days (range, 1–67 days) (Table 1). The EVOLVE radial head system (Wright Medical Technology, Memphis, TN, USA) was used in 10 cases, the Anatomic radial head system (Acumed, Hillsboro, OR, USA) in seven cases, the ExploR radial head system (Zimmer-Biomet, Warsaw, IN, USA) in five cases, and the RHS radial head system (Tornier, Montbonnot-Saint-Martin, France) in two cases.

Additional fixation of adjacent bone and ligamentous injuries was performed for complex elbow injuries. Eleven patients had lateral collateral ligament repair, seven had fixation of the coronoid or the olecranon, two had medial collateral ligament repair, and one had triceps tendon repair. After surgery, patients were immobilized with a splint for 1 week. If no complications including wound problems or instability were present, passive rehabilitation using a hinged brace was begun 1 week postoperatively.

The mean follow-up period for patients was 58.9 months (range, 27–163 months). Clinical outcomes were assessed using the visual analogue scale (VAS) score for pain, the Mayo elbow performance score (MEPS), the quick disabilities of the arm, shoulder and hand (Quick-DASH) score, and active range of motion (ROM) of the elbow joint. For all patients, serial plain radiographs including anteroposterior, lateral, and both oblique views were used to evaluate periprosthetic lucency, heterotopic ossification, arthritic change of the elbow joint, and capitellar wear. Periprosthetic lucency was evaluated based on the number of zones and the amount of lucency around the prosthesis, and it was classified into four types (none, mild, moderate, or severe), as described by Grewal et al. [17]. Heterotopic ossification was graded according to the classification of Hastings and Graham [18]: type 1 does not cause a functional outcome; type 2 has some functional limitation: 2A represents an elbow flexion contracture of 30° or greater and limited flexion of less than 130°, 2B represents limited forearm rotation of less than 50° pronation or less than 50° supination, and 2C represents heterotopic bone causing limitations in both planes of motion; and type 3 has ankyloses that prevent elbow motion. Arthritic change of the elbow joint was assessed on anteroposterior and lateral radiographs at the final follow-up evaluation and classified into four grades (normal, mild, moderate, or severe), as described by Broberg and Morrey [19]. Capitellar wear was graded as none, mild, moderate, or severe, as described by Lamas et al. [20]. Periprosthetic lucency, arthritic change of the elbow joint, and capitellar wear that were above the moderate degree were considered significant. Complications were classified as either minor, those that did not com-

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promise the outcome or require any further treatment, or major, those that compromised the outcome or required a reoperation.

**Statistical Analysis**
Statistical analysis was conducted using IBM SPSS ver. 26.0 (IBM Corp., Armonk, NY, USA). Kendall’s tau B correlation analysis and Mann-Whitney U-tests were conducted to determine the correlations between final clinical scores and various parameters such as age, sex, Mason classification, time interval from initial trauma to surgery, periprosthetic lucency, heterotopic ossification, arthritic change of the elbow joint, and capitellar wear. Statistical significance was set at P < 0.05.

**RESULTS**

**Clinical Outcomes**
At the final follow-up evaluation, the mean VAS score for pain was 0.6 ± 1.1. Fifteen patients had no pain, eight had mild pain, and one had moderate pain. The mean MEPS was 88.7 ± 11.5, with 14 excellent, 9 good, and 1 poor result. The mean Quick-DASH score was 19.4 ± 7.8. The mean ROM was 132.7° ± 7.4° of flexion, 4.7° ± 10.8° of extension, 76.2° ± 10.6° of pronation, and 77.5° ± 5.3° of supination.

**Radiographic Outcomes**
Based on the plain radiographs at the final follow-up evaluation, significant periprosthetic lucency was found in six patients (25%): two moderate and four severe; of the remaining patients, seven had mild periprosthetic lucency, and 11 patients had none. Significant heterotopic ossification that affects functional outcomes was found in four patients (16.7%): two with type 2A and two with type 3; 16 of the remaining patients had type 1, and four patients had no heterotopic ossification. Significant arthritic change of the elbow joint was found in seven patients (29.2%), all moderate, while nine patients had a mild degree of arthritic change and eight patients were normal. Significant capitellar wear was found in five patients (20.8%), all moderate, while 10 patients had mild capitellar wear and nine patients had none (Table 2).

There were no significant correlations between the final clini-
cal scores and various parameters including age, sex, Mason classification, time interval from initial trauma to surgery, periprosthetic lucency, heterotopic ossification, and capitellar wear (P > 0.05). However, arthritis change of the elbow joint was significantly correlated with MEPS (P = 0.047) (Table 3).

Four cases of complications (16.7%) in 24 patients were observed, including two cases of major complications and two cases of minor complications. The two patients with major complications were observed to be a patient with severe arthritis change and a patient with capitellar wear, respectively.

### Table 2. Summary of the outcomes and complications after radial head replacement in patients with complex radial head fracture

<table>
<thead>
<tr>
<th>Case</th>
<th>Periprosthetic lucency</th>
<th>HO</th>
<th>Arthritis change</th>
<th>Capitellar wear</th>
<th>VAS score</th>
<th>MEPS</th>
<th>Q-DASH score</th>
<th>ROM Flexion</th>
<th>Extension</th>
<th>Pronation</th>
<th>Supination</th>
<th>Complication</th>
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<tbody>
<tr>
<td>1</td>
<td>None</td>
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HO: heterotopic ossification, VAS: visual analog scale, MEPS: Mayo elbow performance score, Q-DASH: quick disabilities of arm, shoulder, and hand. ROM: range of motion.

### Table 3. Correlations between clinical outcomes and various parameters

<table>
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<th>Quick-DASH</th>
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<td>0.782</td>
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<tr>
<td>Sex</td>
<td>1.000</td>
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<td>Interval from initial trauma to surgery</td>
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<td>Mason classification</td>
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<tr>
<td>Arthritis change</td>
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<td>Capitellar wear</td>
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VAS: visual analog scale, MEPS: Mayo elbow performance score, Quick-DASH: quick disabilities of the arm, shoulder, and hand.

*Statistically significant.
tions (8.3%) required a reoperation. One patient had stiffness with heterotopic ossification and progressive ulnar neuropathy and underwent arthrolysis and ulnar nerve anterior transposition at 6 months after surgery. The other patient with RHR for open fracture had severe stiffness 3 months after surgery. Four months after surgery, he underwent arthrolysis and removal of the implant for severe ankylosis. The two patients with minor complications had transient ulnar neuropathy but were completely recovered within 4 months.

**DISCUSSION**

The present study revealed that RHR for complex radial head fractures produced satisfactory short to mid-term clinical outcomes, although the rate of radiographic complications was relatively high. Arthritic change of the elbow joint was correlated with clinical scores. The results presented here indicate that RHR is an effective option for treatment of complex radial head fractures.

In complex radial head fractures, the results after ORIF are highly variable and have had many failures [21]. Even a successful ORIF can often result in osteonecrosis of the fragments, failure of hardware which generates stiffness, and unstable or painful elbow [10]. RHR is indicated in cases of unreconstructable isolated radial head fractures and complex elbow injuries [2]. Indications for RHR in the current study were complex radial head fractures with associated injuries including ligamentous injuries, terrible triad injuries, Monteggia fractures, or Essex-Lopresti lesions. Recently, RHR has been widely used in the treatment of complex radial head fractures. However, the use of RHR has been debated due to a relative lack of studies on the long-term outcomes [14,22]. Several reports have compared ORIF and RHR in complex radial head fractures [23,24]. In a systematic review, Dou et al. [11] reported that patients with Mason type III fractures receiving RHR had a significantly higher satisfaction rate compared to those with ORIF, as well as better Broberg and Morrey scores and a lower rate of complications. In a recent systematic review with meta-analysis, Li and Chen [9] reported a higher complication rate for ORIF than RHR for Mason type III fractures (58.1% vs. 13.9%), but the satisfaction rate was higher with RHR than with ORIF (91.7% vs. 51.6%). Bone non-union/bone absorption was the main reported complication of ORIF at 50%.

Tarallo et al. [12] reported on 31 cases of RHR for Mason type III fractures with a mean follow-up of 30 months. Cases presented with good clinical results based on the MEPS: excellent in 77% of the patients, good in 10%, and fair in 4%. Sershon et al. [13] reported on 16 cases of RHR for radial head fractures with a mean follow-up period of 10.5 years with good to excellent MEPS in 15 patients (94%), one patient reporting a fair outcome, and no patients reporting a poor outcome. In the present study, at a mean follow-up of 58.4 months, based on the MEPS, excellent results were obtained in 14 patients (58.3%), good in nine patients (37.5%), and poor in one patient (4.2%). The current findings are consistent with those of previous studies, suggesting that RHR is a reasonable option, producing good clinical outcomes in patients with complex radial head fractures.

Several studies have reported the relationship between radiographic findings and clinical outcomes of RHR [25,26]. Ha et al. [1] performed a 10-year retrospective review of 258 radial head implants in 244 patients. Radiographic complications included heterotopic ossification (46.9%), arthritic change of the elbow joint (27.9%), loosening (19.8%), fracture (2.3%), and hardware dislocation (2.7%). Overall, there were 62 reoperations (24.0%), and heterotopic ossification (53.2%) was the most common cause. A significant correlation between radiographic complications and clinical outcomes was reported. Age, sex, side, and type of arthroplasty did not correlate with either the clinical or radiographic outcomes. Chen et al. [26] reported long-term outcomes after RHR for unreconstructable radial head fractures where 26 of 32 patients had good to excellent results. At a mean follow-up of 8.9 years, the mean MEPS was 83.4 points, and the mean Quick-DASH score was 11.7. Additionally, periprosthetic lucency did not correlate with functional or pain scores. Fehringer et al. [25] reported on 17 patients who underwent metal RHR with smooth stems for comminuted radial head fractures with a minimum 2-year follow-up. Results indicated that “mean stem radiolucency” did not correlate with proximal radial forearm pain. The current study revealed a significant correlation between arthritic change of the elbow joint and MEPS. Periprosthetic lucency, heterotopic ossification, and capitellar wear did not correlate with clinical scores. However, further long-term follow-up studies of a larger scale are needed to account for the possibility of late progression.

Various factors (e.g., patient characteristics and types of RHR implant) that affect clinical outcomes, complications, and reoperation of RHR have been reported. Duckworth et al. [15] reported on 105 patients who underwent RHR for complex radial head fractures. All implants were uncemented monopolar prostheses, with 86% being metallic and 14% being silastic. Twenty-nine patients (28%) underwent reoperation due to one of the following complications: stiffness (n = 12), painful loosening (n = 5), isolated pain (n = 4), subluxation (n = 3), synovitis (n = 2), ulnar neuropathy (n = 2), or infection (n = 1). Results demonstrated that silastic implants and lower age were independent risk factors for
reoperation. Lott et al. [2] retrospectively reviewed 18 stable and 50 unstable elbow injury groups treated with RHR by a single surgeon during a 15-year period. The results showed that the unstable elbow injury group achieved satisfactory functional ROM with no difference in radiographic outcomes, complication rates, or implant survivorship compared with the stable elbow injury group. In a recent systematic review and meta-analysis, Agyeman et al. [27] examined fixation methods to determine if “fixed” or “unfixed” resulted in better clinical outcomes. The results identified 878 unduplicated patients, 522 fixed and 356 unfixed. Implant fixation type did not appear to affect clinical outcomes of RHR. However, rigidly fixing the implant (cement implant) may have increased the risks of reoperation and complications. In the current study, there were no significant correlations between the final clinical scores and age, sex, Mason classification, or time interval from initial trauma to surgery. Because of the small sample size, we could not analyze the outcomes according to implant design. Our overall complication and reoperation rates were 16.6% and 8.3%, respectively, including two cases of major complications (one stiffness with heterotopic ossification and progressive ulnar neuropathy and one stiffness) and two cases of minor complications (two transient ulnar neuropathy). These results were either in line with or better than previous RHR studies.

The current study had several limitations. First, it was a retrospective study with a small number of cases. Second, heterogeneous RHR implants were used, which could have affected clinical outcomes. Third, the follow-up period was relatively short and heterogeneous. Additionally, exact radiographic results that are important in long-term implant survival were not provided. Future long-term prospective studies are needed to evaluate clinical and radiographic outcomes after RHR for complex elbow fractures.

RHR for the treatment of complex radial head fractures yielded satisfactory short to mid-term clinical outcomes, though radiographic complications were relatively high. Results suggest that radiographic complications did not compromise clinical outcomes, and only arthritic change of the elbow joint was correlated with clinical scores. Further long-term studies are needed to fully understand the clinical outcomes and complication rates of RHR.

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15. Duckworth AD, Wickramasinghe NR, Clement ND, Court-Brown CM, McQueen MM. Radial head replacement for acute
Treatment of unusual locked posterior fracture–dislocation of the shoulder: a case series

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Background: Locked posterior fracture–dislocation of the shoulder (LPFDS) is a very rare injury that occurs predominantly in young patients following high-energy trauma. The long-term outcome of the treatment of this injury is often poor. This study sought to present the characteristics of injury, discuss the pathological anatomy, and to report the treatment outcomes of our case series.

Methods: Between January 2012 and May 2018, a total of 234 patients who underwent surgical treatment for proximal humerus fractures were reviewed. Among them, six patients (mean age, 54.7 years; range, 35–76 years) with LPFDS were included in this study. Four patients were treated with open reduction and internal fixation (ORIF) with locking plates, one with hemiarthroplasty, and one with reverse total shoulder arthroplasty. Clinical results were evaluated by Constant, American Shoulder and Elbow Surgeons (ASES), and visual analog scale (VAS) scores and radiologic evaluation was conducted using follow-up radiographs.

Results: The mean length of follow-up was 26.2 months (range, 12–54). The mean Constant, ASES, and VAS scores were 66.7, 65.5, and 2.2, respectively. Four patients who underwent ORIF achieved bony union, but avascular necrosis (AVN) of the humeral head was observed in two patients. No complications were observed in the patients who underwent arthroplasty surgery until final follow-up.

Conclusions: In the treatment of LPFDS, replacement arthroplasty can produce predictable results. The approach of ORIF may be considered as a first choice of treatment in young patients but is sometimes correlated with postoperative complications such as AVN and the functional outcomes may be unpredictable. Therefore, patients should undergo careful diagnosis and treatment of this type of injury.

Keywords: Shoulder; Humerus; Fracture dislocation; Posterior

INTRODUCTION

Dislocation of the shoulder is a common injury, with most cases being anterior dislocation. Posterior dislocation of the shoulder (PDS) is a rare injury accounting for only 2% to 5% of all shoulder dislocations in the literature [1]. Meanwhile, posterior fracture–dislocation of the shoulder affected 0.9% of 1,500 cases reported by Neer, which is rarer [2,3]. The mechanisms of PDS can be classified as atraumatic and traumatic. The latter is mostly caused by high-energy trauma, while fracture is usually caused by axial loading, with the arm in an adducted, flexed, and internally rotated position [4].

In PDS, impacted articular fracture of the humeral head (reverse Hills-Sachs lesion) (Fig. 1) was the most common associat-
ed feature, followed by humeral neck fractures, lesser tuberosity fracture, and greater tuberosity fracture [5]. In some cases, the lesion is complicated by a proximal humeral fracture, usually at the level of the anatomical neck. Some authors defined this injury as a locked posterior fracture-dislocation of the shoulder (LPFDS) or complex posterior fracture-dislocation of the shoulder (Fig. 2) [6,7].

Since LPFDS is not commonly seen in daily clinical practice, early diagnosis is often missed [6] and there is no gold-standard treatment for LPFDS. Existing treatments vary from closed reduction and pinning to open reduction and internal fixation (ORIF) to replacement arthroplasty [8]. Arthroplasty has often been preferred over ORIF, especially among elderly patients because the results are predictable and severe complications such as nonunion or avascular necrosis (AVN) of the humeral head can occur after ORIF. However, according to recent studies, these complication rates have decreased as compared with previous reports [8]. The results of successful osteosynthesis surgery were superior to joint-replacement surgery; therefore, ORIF should be considered as a first-choice treatment in young patients with this type of injury. The authors of the present report experienced six cases with this rare type of injury in combination with a Neer four-part fracture. This study aimed to present the characteristics of injury, discuss the pathological anatomy, and report the treatment outcomes of our case series.

METHODS

This study was approved by the Institutional Review Board of Uijeongbu St. Mary's Hospital (IRB No. UC20RAS10120). Owing to the retrospective design, the requirement for informed consent was waived.

The medical records of 234 patients who underwent surgical treatment for proximal humerus fracture between January 2012 and May 2018 were reviewed retrospectively. During this period, patients who had undergone surgery for LPFDS and participated in follow-up for more than 6 months were included in this study. Six patients were identified and included in the study. The mean age was 54.7 years (range, 35–76 years) and three patients each of six total were male and female, respectively. The injury mechanisms included atraumatic seizure (n = 1), motorcycle accident (n = 3), car accident (n = 1), and a fall from a 3-m height (n = 1), respectively (Table 1).

One orthopedic shoulder surgeon (CGK) performed all operations. Under general anesthesia, a deltopectoral approach was used in all patients. ORIF using a PHILOS plate (DePuy Synthes, Oberdorf, Switzerland) was performed in four patients (Figs. 2-5), hemiarthroplasty (Aequalis; Tornier, Minneapolis, MN, USA) in one patient (Fig. 6), and reverse total shoulder arthroplasty (Aequalis, Tornier) in one patient (Fig. 7). The clinical re-

Fig. 1. A three-dimensional computed tomography scan of the shoulder shows an impacted articular fracture of the humeral head known as a reverse Hill-Sachs lesion (black arrow) and a fracture fragment (white arrow).

Fig. 2. Imaging of patient 1: preoperative X-ray (A), pre- and postoperative three-dimensional computed tomography scans (B, C), and postoperative X-ray (D).
Table 1. Characteristics of the patients, fracture type, surgery methods, and results at the final follow-up visit

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<th>Surgery</th>
<th>Follow-up (mo)</th>
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VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons, ORIF: open reduction and internal fixation, AVN: avascular necrosis, RTSA: reverse total-shoulder arthroplasty.

Fig. 3. Imaging of patient 2: preoperative X-ray (A), pre- and postoperative three-dimensional computed tomography scans (B, C), and postoperative X-ray (D).

Fig. 4. Imaging of patient 3: preoperative X-ray (A), pre- and postoperative three-dimensional computed tomography scans (B, C), and postoperative X-ray (D).

Fig. 5. Imaging of patient 4: preoperative X-ray (A), pre- and postoperative three-dimensional computed tomography scans (B, C), and postoperative X-ray (D).
Results included Constant, American Shoulder and Elbow Surgeons (ASES), and visual analog scale (VAS) scores collected at the final follow-up visit after surgery. The radiologic evaluation was conducted using follow-up radiographs for evaluating bony union and complications such as delayed union, nonunion, AVN of the humeral head, metal failure, or implant loosening.

RESULTS

The mean length of follow-up was 26.2 months (range, 12–54 months). The mean Constant, ASES, and VAS scores at the postoperative final visit were 66.7 (range, 43–93), 65.5 (range, 39–92), and 2.2 points (range, 0–4), respectively (Table 1). In this study, the sample size was too small (n = 6) to conduct statistical analysis. However, we could not analyze or compare the subjective outcomes score according to the patient groups. Two patients who underwent joint-replacement surgeries showed no radiological complications until the last follow-up and their mean Constant, ASES, and VAS scores at the postoperative final visit were 66.5, 65, and 2.5 points, respectively.

Four patients who underwent ORIF achieved bony union of fracture site radiologically and their mean Constant, ASES, and VAS scores at the postoperative final visit were 65, 67.5, and two points. Among these four patients, AVN of the humeral head was observed at 6 months (patient 1) and 9 months (patient 3) after ORIF surgery, respectively, and penetration of the screws into the joint was observed in these patients. Therefore, the clinical scores in these patients were lower. One individual (patient 1) underwent an additional operation for screw replacement at six months after the initial operation and AVN was observed at final follow-up (Fig. 8). The other patient refused additional surgery and has remained under observation (Fig. 9).

DISCUSSION

We reviewed six patients with LPFDS in this study. This rare injury often occurs in relatively young patients following high-energy trauma; therefore, a cautious approach to treatment is needed. Previous reports have shown that closed reduction under general anesthesia produces good results in acute cases [1,9,10]. However, good results in cases of this locked type of fracture–dislocation injury are difficult to achieve by closed methods and there are many factors to consider when performing surgical treatment.

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Analyzing the pattern of fracture will help with understanding the mechanism of injury. In the present study, all patients were classified as four-part fractures of the Neer classification [3]. As reported by previously published studies [1,6], preoperative three-dimensional computed tomography (3D CT) findings in our series cases show consistent fracture patterns. The fracture occurred in the anatomical neck and articular surface of the humeral head faced posteriorly. Fractures of greater and lesser tuberosity were observed; however, they were nondisplaced or minimally displaced. It can be assumed that the reasons for why this fracture pattern occurred during the series included processes of dislocation and reduction of the posterior dislocation. It can be supposed that the fracture begins at the anterior osteochondral lesion of the anatomical neck and then the humeral head becomes locked into the posterior glenoid rim. Next, the fracture was extended posteriorly by reduction force, leading to a complete fracture of the humeral head and, subsequently, the greater tuberosity, the lesser tuberosity, and the shaft. Finally, the humeral head remained in a displaced position, facing posteriorly. This fracture pattern is similar to the principle of opening a bottle cap.

Due to unique characteristics of the fracture, the closed method exhibits difficulty in reducing the locked articular fragments and achieving good results, which usually requires open-reduction surgery. Decisions will be needed on whether to perform osteosynthesis surgery or to perform the joint replacement surgery before or during surgery. Joint-replacement surgery can be considered in the context of chronic or neglected LPFDS, a severe fracture to the articular surface (> 50%), or elderly patients [11]. In the past, hemiarthroplasty or anatomical total shoulder-replacement surgery have often been performed to address this type of injury. Recently, however, reverse total-shoulder arthroplasty (RTSA) surgery has produced more reliable results for both proximal humerus fractures [12] and for this type of injury. In this study, the operation method was chosen mainly according to the patient’s age. The average age of the two patients who underwent replacement surgery was 76 years old, while those who underwent osteosynthesis surgery were on average 44 years old. The final clinical results of patients who underwent replacement surgery were similar to those of the patients who underwent osteosynthesis surgery without AVN. The RTSA patient showed better clinical results than the patient who underwent hemiarthroplasty surgery.

In this study, the incidence rate of AVN of the humeral head after ORIF was higher than that in other recent published studies [6,7]. However, the number of ORIF procedures (n = 4) included in this study was too small to compare with other studies. Although it is difficult to accurately compare the outcomes of this rare injury among studies, the cases in this study included Neer four-part fractures, which are marked by high rates of complications. Further, the use of a deltopectoral approach would have led to longer surgical times with additional soft-tissue damage, while the selection of bone-graft material may have affected the results.

Our retrospective analysis of the patients included herein showed that there were many factors to consider. Once the osteosynthesis surgery is decided, several factors can drive better outcomes. First, surgery should be performed as soon as possible so that it can be completed without swelling or muscle contractures [7]. This will prevent further damage to the soft tissue and bone. Second is the surgical approach. The deltopectoral approach, which has been widely used in shoulder surgery, was adopted in
all current cases. However, as reported in previous literature, this approach shows some problems when treating this type of injury [13-15]. Specifically, there is a limitation to securing posterior space because this approach is done through the anterior intermuscular plane. The humeral head is locked in the posterior rim of glenoid and it is very difficult to restore the joint surface from the posterior direction. In this case series, the ORIF surgery took longer (average, 128 minutes) than replacement surgery (average, 96 minutes) to perform. Depending on our experience and other authors’ reports [7], different approaches may be warranted to facilitate easy and rapid reduction of the humeral head. Although closed, percutaneous, or arthroscopy-assisted techniques have been introduced, we believe that direct identification of the fracture site is a safe and certain way to treat this type of injury. Third is the fixation method. In this study, locking plates (PHILOS plate; Depuy Synthes, Johnson & Johnson, Oberdorf, Switzerland) were used. Conversely, in the first report of this type of injury, compression screws were used [13] and, later, traditional plates were used. Since it has been reported that it is excellent to use locking plates for proximal humerus fixation in both normal and osteoporotic bone [16,17], this type of injury requires locking plate fixation. Finally, the choice of bone graft is one of the factors that can affect the results because bone defects are often seen in this type of injury. In this study, allograft bone-chip grafting was performed for bone defects found at the site of fracture. Although bony union was achieved in all ORIF cases, osteonecrosis with screw penetration occurred in two of the four cases. It was assumed that the allograft bone chip could serve as filler, but the level of biomechanical support during fracture healing apparently was insufficient. Recently, there have been many reports of excellent results when using fibular allograft in proximal humerus fractures [18]. We believe that such could be considered as one of the options for bone grafting in this type of injury.

There are limitations to this study. Due to the rarity of this injury, only a few patients were included. Young to middle-aged patients underwent surgery to obtain osteosynthesis, while elderly patients underwent replacement surgery; as such, it was difficult to compare each technique. It is believed that due to various surgical treatment methods, the same rehabilitation protocols were not applied in all cases, which could have affected the treatment outcomes. Second, a longer follow-up period would have yielded more reliable rates of complications and prognosis. In particular, the rate of complications such as osteonecrosis and traumatic osteoarthritis could have increased if longer follow-up was designated for the ORIF patients. Finally, a small number of cases made it difficult to complete a meaningful comparison. It is believed that a large multicenter, randomized, controlled study is necessary in the future to analyze various factors affecting the results.

LPFDS is a rare form of injury, with few literature reports available that discuss its management. During diagnosis, a 3D CT scan will help to identify the pattern of injury. When ORIF surgery is applied to young patients, efforts should be made to avoid complications such as osteonecrosis. Making choices regarding parameters such as the surgical approach, implant system, bone-grafting method for shortening the surgical time, and rigid fixation may affect the postoperative surgical outcomes; therefore, these decisions should be made carefully.

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Physicians developed reverse total shoulder arthroplasty (RTSA) to treat rotator cuff tear arthropathy accompanied by glenohumeral arthritis caused by massive rotator cuff tear in elderly patients [1]. As favorable outcomes have been reported in terms of pain abatement and function, the range of applicability for RTSA has broadened; as a result, physicians are performing more of these procedures, which has led to increase in complications [2]. The most common problem of this technique is scapular notching, which is seen often in cases of reverse shoulder implant based on the Grammont design. Complications that require additional surgery such as revision arthroplasty include instability, infection, and implant loosening [3], and physicians usually perform revisions using the same type of implant as used previously. The authors of the present study performed a partial revision in a case involving instability with scapular notching and glenoid aseptic loosening using glenoid and humerus components from different manufactures and achieved favorable outcomes.

Keywords: Reverse shoulder arthroplasty; Notching; Dislocation; Polyethylene wear; Revision

CASE REPORT

Owing to the retrospective design of this study, approval of the Institutional Review Board was waived. Before surgery, consent was obtained from the patient for this study. A 71-year-old man was admitted for instability in the right shoulder that had gradually worsened. The patient was very anxious about possible dislocation of his right shoulder from minor trauma, such as coughing. A review of his medical history showed arthroscopic cuff repair and debridement 6 years prior for massive rotator cuff tear and mini-open cuff repair for cuff re-tear. However, because there was no improvement in his symptoms, he underwent RTSA on his right shoulder in October 2010, using a shoulder replacement system (Zimmer Inc., Warsaw, IN, USA) based on Grammont's design (Fig. 1A).

The patient had no other symptoms when he suffered a dislocation. He underwent manual reduction in the emergency room...

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and was discharged. However, the same dislocation occurred four more times in 6 months (Fig. 1B). At the time of admission, his range of motion consisted of active forward flexion of 80° and abduction of 40°, while internal rotation was identified as the greater trochanter of the femur. On radiologic examination, the glenoid surface was located superiorly during the first RTSA, baseplate loosening was accompanied by superior migration after recurrent dislocation, and progressive scapular notching (grade 4, Nerot-Sirveaux grading system) was identified.

Other than these problems, the humerus implant appeared to be stable (Fig. 2). A revision surgery was planned to address the recurrent dislocation and accompanying glenoid side problem. For recovery of stability through appropriate recovery of tension in the deltoids, the humerus was planned to be moved to a more distal and lateral position. For the glenoid side, the plan was to prevent inferior scapular notching and implant loosening by increasing the inferior tilt of the glenoid and positioning the baseplate more inferiorly. Due to a large bone defect due to glenoid notching, use of the existing baseplate would have required a large autologous bone graft.

However, it was determined that using the same size or larger baseplate after applying a large amount of autologous bone graft may cause unstable fixation. Thus, a DJO Surgical Reverse Shoulder Prosthesis (DJO Surgical, Austin, TX, USA) that has a smaller baseplate than the existing one but the same glenoid hemisphere size was chosen as the implant. Moreover, because the DJO Surgical Reverse Shoulder Prosthesis is an implant that has its center of rotation closer to the anatomical center than the existing implant based on the Grammont design, it is expected to contribute to shoulder stabilization by providing lateral movement by the humerus. The deltopectoral approach that had been used previously was employed with the patient in the beach chair position under general anesthesia. Culture tests on tissues and frozen biopsy were performed to test for infection. Since humeral implant loosening was not observed, it was left intact, and the polyethylene liner and socket were removed for the glenoid side approach. During the removal process, polyethylene liner wear was confirmed (Fig. 3A). After separating the glenoid hemisphere from the baseplate, the screws and baseplate were removed. Step-like bone defect from impingement on the inferior glenoid and a central peg hole were identified (Fig. 3B). The central hole was filled by an autologous iliac bone graft, and the baseplate was positioned as inferiorly as possible during fixation to the glenoid to produce an inferior tilt.

Reduction was performed after confirming that the thickness was appropriate by inserting a polyethylene trial into the humeral implant. The suitability of polyethylene thickness was evaluated by considering the tension of the conjoint tendon when the humerus was externally rotated and tracted downward. After inserting the metallic spacer and thick polyethylene, the subscapularis tendon and anterior soft tissues were re-sutured (Fig. 4). After surgery, the patient wore an abduction brace for 6 weeks, during which only pendulum exercise was allowed in the shoulder. Active exercise was recommended for the elbow, wrist, and hand to control for swelling. After 6 weeks, the brace was loosened, and active assistive joint exercise was performed. From postoperative 3 months, movements necessary for activities of daily living were allowed based on pain tolerance. When the patient visited 6 months later, he reported no discomfort; at postoperative 4 years, he showed active forward flexion of 150°, abduction of 100°, and internal rotation of L2, increases from preoperative levels (Fig. 5). No other postoperative complication was
Complications after RTSA include scapular notching, postoperative instability, infection, periprosthetic fractures, glenoid or humerus implant loosening or fracture, screw loosening, acromion or scapular spine fractures, hematoma, heterotrophic ossifications, and nerve damage [2]. Among these, scapular notching is the most common and occurs due to mechanical impingement between the inner surface of the humeral cup and the lateral scapula pillar below the glenoid hemisphere, and the Grammont design tends to induce such impingement [4]. Some results indicate that scapular notching may have a negative impact on surgical outcome, but most indicate that it does not affect surgical outcome; the findings are inconsistent [5]. Unlike the Grammont design, the DJO Surgical Shoulder Prosthesis has a center of rotation close to the anatomical center and appears capable of preventing glenoid notching [3].

Instability is one of the major complications requiring surgical treatment [3]. Some authors have reported that the deltopectoral approach has a negative effect [6], but the observation of subscapular tendon rupture, fat degeneration, and brachial angulation in the reported cases, so we can suggest that the approach will not be a significant factor [3]. Another cause is dislocation from loosening of the tension in the deltoids. It is believed that this is due to preoperative deltoid dysfunction, humeral shortening found.

DISCUSSION

Complications after RTSA include scapular notching, postoperative instability, infection, periprosthetic fractures, glenoid or humerus implant loosening or fracture, screw loosening, acromion or scapular spine fractures, hematoma, heterotrophic ossifications, and nerve damage [2]. Among these, scapular notching is the most common and occurs due to mechanical impingement between the inner surface of the humeral cup and the lateral scapula pillar below the glenoid hemisphere, and the Grammont design tends to induce such impingement [4]. Some results indicate that scapular notching may have a negative impact on surgical outcome, but most indicate that it does not affect surgical outcome; the findings are inconsistent [5]. Unlike the Grammont design, the DJO Surgical Shoulder Prosthesis has a center of rotation close to the anatomical center and appears capable of preventing glenoid notching [3].

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Fig. 3. Revision surgery. (A) Intraoperative views showing the inferior side of the polyethylene liner was worn out and (B) glenoid side large bone loss and exposed screw.

Fig. 4. Anteroposterior radiograph showing the exchanged glenoid component, inserted metallic spacer, and thicker polyethylene liner. The glenoid prosthesis that was used for the glenoid side was different from the primary reverse total shoulder arthroplasty but compatible with the primary prosth.

Fig. 5. Follow-up 4 years after partial mixed revision surgery.
ing from various factors that cause proximal humeral defect, or medial translation of the humerus [2]. Therefore, when planning revision surgery, humeral shortening or medial translation should be assessed and confirmed from radiologic examination of the humerus bone and should be measured to make the necessary preoperative preparations [7]. Moreover, to induce adequate tension in the deltoids during revision, it is necessary to insert a humeral implant metallic spacer, a thick polyethylene liner, or an even longer humeral implant to lengthen the humerus or to use a hemisphere that is bigger or located more laterally to position the humerus more laterally [2].

In the present case, the existing glenoid implant was implanted into the patient with a superior tilt, allowing glenoid implant dissociation from shearing forces, resulting in instability from bone loss caused by joint notching and dislocation. Because the patient underwent RTSA on both sides, assessment of the humerus on both sides by preoperative radiologic examination was difficult, and appropriate tension on the deltoids was only assessed intraoperatively. Although the humeral length could be increased by inserting a metallic spacer or a thick polyethylene liner, because it was accompanied by a glenoid side bone defect, it was difficult to use a large hemisphere. Thus, an implant that can use a smaller baseplate and has a center of rotation more lateral than the implant based on the Grammont design was selected to achieve stability by shifting the humerus more laterally. When using the two types of implants, the glenoid hemisphere and polyethylene cup sizes were the same. Although conformity may vary, we believe that there will not be any problem with wear since the shoulder is not a weight-bearing joint. Instability after RTSA can be treated by inserting appropriate implants to prevent inferior capsular notching and glenoid side loosening.

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Calcific tendinitis of the rotator cuff is a common disease that can cause severe shoulder pain. Calcification has been rarely reported in elderly patients, and the age group with the most frequent outbreaks experience issues such as rotator cuff tears and calcific tendinitis [1]. Although other joints can be affected, calcific tendinitis occurs most often in the shoulder joint, and it frequently occurs in the supraspinatus, infraspinatus, teres minor and subscapularis tendons in descending order. Additionally, the long head of the biceps tendon is a rare location of calcific tendinitis.

Calcific tendinitis is more common in people between 30 and 60 years of age, and one report described a large number of patients who had less active occupations or were housewives, with most cases in the right shoulder [2]. The acute symptoms subside in 1 to 2 weeks, even in the absence of treatment, and symptoms can change rapidly [3,4]. The main symptoms are acute severe shoulder pain and limited range of motion (ROM). However, in 20% of cases, it is radiologically confirmed but asymptomatic. The fate of acute calcific tendinitis is spontaneous resorption of the calcific deposit.

The natural history of calcific tendinitis is divided into three phases: the acute phase, subacute phase, and chronic phase. Uhthoff divided calcific tendinitis into three distinct stages: the pre-calcific stage, calcific stage, and post-calcific stage [5]. Furthermore, the calcific stage was subdivided into the formative, resting, and absorptive stages. Most patients report severe symp-
toms during the absorptive stage. The calcific stage corresponds to a healing period during which resorption of calcified deposits takes place.

On the other hand, the fate of a calcific deposit on the labrum might be different from that of a conventional calcific deposit on the rotator cuff. During the formative phase, the area of fibrocartilage with the foci of calcification is generally devoid of vascular channels [5]. The posterosuperior labrum is also devoid of vascular channels, and the formation of a calcification on it could be different from calcific tendinitis of the rotator cuff tendons. Calcific tendinitis of the glenoid labrum is a rare disease entity. The management of calcifications in unconventional locations might be different from calcific tendinitis of the rotator cuff. Although spontaneous resorption of calcification at the long head of the biceps tendon has been reported, another reasonable treatment modality could be considered if conservative treatment is not effective [6]. We report a case of calcific tendinitis of the posterosuperior glenoid labrum in a 39-year-old man, and we also review the literature.

**CASE REPORT**

A 39-year-old man visited our clinic complaining of severe shoulder pain. He reported 1 week of conservative treatment that included oral medication, an injection, and physiotherapy, including extracorporeal shock wave therapy (ESWT), transcutaneous electrical nerve stimulation and cold pack massage, in a local clinic. However, the patient’s symptoms had not improved. Laboratory data, including erythrocyte sedimentation rate and C-reactive protein, were normal. On physical examination, severe shoulder pain and limited ROM were observed; the patient could not elevate his arm. In addition, he reported that he could not sleep comfortably.

An X-ray showed a round-shaped calcific deposit near the supraglenoid tubercle of the glenoid in the shoulder joint. Magnetic resonance imaging (MRI) revealed a calcific deposit in the posterosuperior labrum of the shoulder joint (Fig. 1). Because conservative treatment had failed, additional treatment options were discussed, and the patient elected surgical treatment and underwent arthroscopic removal of the calcific deposit in the long head of the biceps tendon.

This study was approved by Institutional Review Board of Daejeon St. Mary’s Hospital and informed consent was obtained from the patient included in this study.

**Arthroscopic Surgery**

The patient was positioned in the lateral decubitus posture with approximately 10 lbs of lateral traction. Conventional arthroscopic evaluation was performed through the posterior portal. Because the preoperative MRI had demonstrated calcified deposits in the posterosuperior labrum, this area was carefully inspected with the probe. Arthroscopic findings showed swelling and hyperemia of the joint capsule, and the posterosuperior labrum had a strawberry-like appearance (Fig. 2A). The labrum was carefully probed and palpated with the probe. An 18-gauge needle was inserted through the port of Wilmington, and the calcific deposit was carefully approached from the anterior to the posterior labrum. Needling on the calcific deposit was repeated several times to widen the exit point of calcific deposits. Next, the sharp tip of the probe was inserted through the opening, and the calcific de-
posit was removed by moving the tip of probe (Fig. 2B). A shaver was inserted for removal of the remaining calcific deposit in the labrum by marginal resection of the calcific deposit (Fig. 2C). The calcific deposit was completely removed during surgery, and 6-month follow-up radiographs and an MRI did not show any evidence of a calcific deposit in the postero-superior labrum (Fig. 3).

**DISCUSSION**

We experienced an isolated calcific tendinitis at the postero-superior labrum that was successfully treated by arthroscopic calcific deposit removal. After arthroscopic treatment, the patient’s severe pain immediately and completely disappeared, and follow-up radiologic findings showed no recurrence of calcific tendinitis.

Typically, calcific tendinitis is described in the rotator cuff tendons and, to a lesser extent, in the long head of the biceps tendon, the pectoralis major, and the trapezius. It is commonly seen in patients in their fourth to fifth decade, and resorption usually occurs spontaneously without any intervention. Calcific tendinitis of the long head of the biceps tendon is uncommon and rarely reported. Cho and Rhee et al. [7] reported a large calcific deposit in the superior glenoid labrum of the shoulder, and arthroscopic removal of the calcific material completely alleviated the patient’s pain. Kim et al. [8] reported calcific tendinitis of the long head of the biceps brachii associated with a superior labral tear from anterior to posterior (SLAP) lesion in a 41-year-old patient. The calcium deposit was removed and the SLAP lesion was repaired with a suture anchor arthroscopically. Ji et al. [9] reported calcific tendinitis of the biceps-labral complex, which is a rare cause of shoulder pain and requires arthroscopic debridement of the calcific material for resolution of symptoms. Amri et al. [6] reported spontaneous resorption of a calcification in the long head of the biceps tendon that had been treated by a conservative approach.

The treatment of such calcific tendinitis included non-steroidal anti-inflammatory drugs (NSAIDs), ESWT, physiotherapy, needle lavage, or arthroscopic removal of the calcific deposit. Treatment of calcific tendinitis is divided into nonsurgical treatment and surgical treatment. First, conservative treatment such as NSAID, physical therapy, ultrasound and ESWT was performed. Ogon et al. [10] reported that negative prognostic factors for patients undergoing conservative treatment were bilateral occurrence of calcific tendinitis of the shoulder, localization to the anterior portion of the acromion, medial (subacromial) extension, and high volume of the calcific deposit and a calcification that is not confirmed by ultrasound.

In our clinic, we evaluate for the presence or absence of these prognostic factors, and then we consider surgical or conservative treatment. For patients in the acute phase, NSAIDs should be used for pain control, and passive ROM should be provided through physical therapy to prevent stiffness of the shoulder.

Fig. 2. Arthroscopic findings of isolated calcific tendinitis at the posterosuperior labrum. (A) Arthroscopy showed swelling and hyperemia of the capsule, and the posterosuperior labrum had a strawberry-like appearance. (B) The calcific deposit was removed with the probe tip. (C) Finally, a shaver was inserted to remove the remaining calcific deposit by performing marginal resection of the deposit and capsule.

Fig. 3. Follow-up radiologic findings of isolated calcific tendinitis at the posterosuperior labrum. (A) A postoperative X-ray showed only a small trace of the calcific deposit (arrow). (B) Follow-up magnetic resonance imaging showed no evidence of the calcific deposit (arrow).

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joint. Local steroid injections have been reported to be effective, and they also have been reported to interfere with calcification [1] and are still controversial. In most cases, conservative treatment relieves the patient's symptoms, and Cho et al. [11] reported that symptoms improved with conservative treatment in about 72% of patients. However, the period or type of conservative treatment can vary depending on a patient's tolerance or activity. If a patient cannot tolerate severe pain and/or has no time for conservative treatment, surgical treatment can be considered.

Farin et al. [2] introduced ultrasound-assisted bursal lavage and needling therapy. Ultrasound-assisted needling is often used to treat calcific tendinitis because it can be performed at a relatively low cost under local anesthesia on an outpatient basis. One recent systematic review [12] showed that there is a large variation between studies using ultrasound-assisted needling, thus additional high-quality studies are required for low-quality evidence. ESWT has been used as a treatment for calcific tendinitis since the 1990s. Krasny et al. [13] studied the results of treatment with ESWT, ESWT and ultrasound-guided needling, and reported that combined treatment was more effective and resulted in fewer patients requiring surgical treatment.

Surgical treatment may be considered if conservative treatment fails or if the symptoms persist. Although removal of calcified material using an incision is effective, arthroscopic treatment has similar results and minimizes deltoid complications. Arthroscopic treatment is becoming more popular. We described a 39-year-old male patient with calcific tendinitis of the posterosuperior labrum who was treated with arthroscopic removal of the calcific deposit after a 1-week period of failed conservative treatment. Compared to the conventional calcific tendinitis of the rotator cuff, the location of these glenoid labrum was too deep in the glenohumeral joint. In addition, the patient received injection therapy, but his pain was not relieved. Due to the deep location of the calcific deposit in the glenoid labrum, conservative treatment, including ESWT and injection, may not be effective. In this case, ultrasound-guided barbotage or arthroscopic treatment may be considered.

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Simple clavicle shaft fractures can achieve satisfactory results through conservative treatment, and the less frequency of nonunion. Non-union or malunion can occur in displaced clavicle fractures or comminuted shaft fractures. Treatment of displaced comminuted clavicle shaft fractures is performed by holding together the free fragments with interfragmentary screws or wires and fixing them to the clavicle with a plate. Therefore, we performed interfragmentary fixation using open reduction and internal fixation with bioresorbable screws (Mg-Ca alloy, Resomet bioresorbable bone screw; U&I Corp.) and bioresorbable wires (Mg-Ca alloy, Resomet bioresorbable K-wire and pin, U&I Corp.) for displaced comminuted clavicle fractures (Robinson type 2B) and additionally used a metal plate. We expected decreased irritation and infection due to absorption after surgery. We report four cases that were treated in this way.

**Keywords:** Clavicle; Midshaft fracture; Comminuted fracture; Interfragmentary screw; Bioresorbable screw

Simple clavicle shaft fractures can be treated conservatively and typical involve minimal complications [1]. However, the incidence rate of displaced fracture and comminuted fracture in the clavicle caused by high energy injury has increased recently, and there is high likelihood of malunion or non-union, such as angulation or shortening [2,3]. Successful results have been reported with use of a metal plate, screw, or intramedullary nailing after open reduction [4,5]. As a result, such surgical treatment has been increasing [6,7]. If there are multiple comminuted fragments (such as Robinson type 2B), metal plate fixation is preferred. However, if open reduction is performed solely for plate fixation, soft tissue and periosteal detachment may be severe, imparting a high chance of nonunion or metal failure. To prevent those complications, interfragmentary screws are generally used between broken bones. Metal implants can irritate the surrounding tissue of fixed bones or can lead to difficulties in removing the fixed implant after bone union.

Therefore, bone union and improvement in symptoms were identified in four cases of Robinson type 2B clavicle shaft fracture that were treated using bioresorbable screws (Resomet bioresorbable bone screw, U&I Corp., Seoul, Korea) and K-wires and pins (Resomet bioresorbable K-wire and pin, U&I Corp.) (Fig. 1) to perform reduction and fixation, followed by fixation to a metal plate.

**CASE REPORT**

Owing to the retrospective design of this study, approval of the Institutional Review Board and the requirement for informed consent were not obtained. IRB approval: None.

Financial support: None.

Conflict of interest: None.
Case 1
A 72-year-old male patient fell off the bed after arthroscopic surgery for a right torn rotator cuff and experienced pain in the left clavicle area. Radiological images showed a Robinson type 2B2 fracture with 10-mm displacement and shattered bones (Fig. 2A). Before surgery, consent was obtained from the patient for use of the resorbable implant. For surgery, general anesthesia was used, and the patient was placed in a beach chair position. The surgical area was exposed, and the arm of interest was placed to allow free movement. Using a C-arm intensifier, the fracture location was checked from multiple angles and a skin incision was performed. Next, the excised skin was opened to expose the fractured area. Reduction was performed on the broken bones, and two resorbable bone screws and a resorbable K-wire and pin were used to readjust the bones to a simple fracture from a comminuted fracture (Fig. 2B and C). A metal plate (TDM clavicle shaft plate; Salt Lake City, UT, USA) was used to fix the clavicle (Fig. 2D). After surgery, an arm sling was worn, and the patient started joint exercises based on tolerance to suture stability and pain. At 1 month after surgery, the pain had disappeared; range of motion was not limited at 10 weeks of follow-up. Radiological imaging showed successful bone union (Fig. 2E).

Case 2
A 74-year-old male patient was admitted to the emergency room due to right shoulder pain after falling from his motorcycle. Radiological findings were a Robinson type 2B2 right clavicle shaft fracture with 20-mm displacement (Fig. 3A). Surgery was performed as stated for the case 1 patient, and a resorbable bone screw and resorbable K-wire and pin were used to fix the bone fragments, which were then stabilized on a metal plate (Synthes LCP superior–anterior clavicle plate 8H; Synthes, Oberdorf, Switzerland) and fixed to the clavicle (Fig. 3B, C). Post-surgery rehabilitation was conducted as for the case 1 patient, and no pain was reported in the operated area at 45 days after surgery (Fig. 3D). The patient showed no restriction of range of motion, and bone union was achieved at 9 weeks of follow-up (Fig. 3E).

Case 3
A 72-year-old male patient was admitted to the emergency room due to pain in his left shoulder after falling. Radiological imaging showed a Robinson type 2B2 left clavicle shaft fracture with 10-mm displacement. The same surgical procedure was conducted, and a resorbable bone screw, K-wire, and pin were used to fix the bones to a simple fracture from a comminuted fracture (Fig. 2A). A metal plate (TDM clavicle shaft plate; Salt Lake City, UT, USA) was used to fix the clavicle (Fig. 2D). After surgery, an arm sling was worn, and the patient started joint exercises based on tolerance to suture stability and pain. At 1 month after surgery, the pain had disappeared; range of motion was not limited at 10 weeks of follow-up. Radiological imaging showed successful bone union (Fig. 2E).

Fig. 1. Bioresorbable implant. (A) Bioresorbable screw. (B) Bioresorbable wire.
broken bones. A metal plate (Synthes clavicle end plate 8H) was used to fix the broken bones to the clavicle, and post-surgery rehabilitation was conducted as above. The patient reported no pain 7 weeks after surgery, and bone union and full range of motion of the operated shoulder were observed at 11 weeks of follow-up. No complications were noted at 1-year follow-up.

Case 4
A 73-year-old male patient was admitted to the emergency room due to pain in his right shoulder after falling. Radiological imaging showed a Robinson type 2B2 left clavicle shaft fracture with 18 mm displacement. The same surgical procedure was conducted, and a resorbable bone screw, K-wire, and pin were used to fix the broken bones. A metal plate (TDM clavicle shaft plate 9H) was used to fix the bones to the clavicle, and post-surgery rehabilitation was conducted as in the above cases. The patient reported no pain at 40 days after surgery, and bone union and full range of motion of the operated shoulder were observed at 13 weeks of follow-up. No complications were reported at follow-up.

DISCUSSION
Traditionally, clavicle shaft fracture was treated conservatively with a figure of 8 bandage or with an arm sling, and surgical procedures were thought to be the cause of bone nonunion [8]. However, when displacement is severe or there are many fragments, non-surgical treatments showed a 15%–20% bone nonunion rate compared to the much smaller bone nonunion rate (2%–3%) of surgical approaches [3]. Therefore, surgery was performed in cases of Robinson type 2B fracture with multiple fragments and comminution, who were high activity and smooth shoulder movements before injury. The bone nonunion that occurs after surgery is thought to be caused by severe soft tissue and periosteal detachment [9]. To minimize these events, non-invasive reduction with intramedullary fixation [10] or minimal invasive plate osteosynthesis (MIPO) with locking compression plate is utilized [11].

However, for severe comminuted fracture, noninvasive reduction with intramedullary fixation is not a viable option because the fixation process is difficult, the fixture stability is weak, and the anti-rotation power is weak. Thus, open reduction is performed for Robinson type 2B fracture, reserving MIPO for special cases (e.g., refracture). Additional precautions are needed during rehabilitation after this procedure, and there are more possible complications such as displacement of the pin and shortening of the clavicle. Furthermore, minimally invasive surgical procedures use a locking compression plate as an indirect fixation method can be problematic and can result in difficulties in properly fixing the plate in the absence of proper analysis of the anatomical structure of the clavicle. Furthermore, percutaneous reduction is difficult for novices and requires ample experience. Additionally, iatrogenic damage can occur at the blood vessels under the clavicle, the nerves, and the lungs, indicating the need for caution.

Koh et al. [12] reported that comminuted clavicle shaft fracture can be more effectively and accurately treated with open reduction to clearly localize the bone fragments. Reduction then can be performed at the specific area, the free fragments can be attached using cannulated or mini screws, and the whole bone can be stabilized against a metal plate. However, to fix all the bone fragments, one to more than four screws might be used, in addition to six or more than 10 screws to fix the plate. This excessive use of screws may lead to irritation and difficulties in removing the implant after bone union or if complications arise. Even when screws are successfully removed, loss of such a volume of material can leave the bone hollow and weak, imparting a higher chance of fracture recurrence. Rather than removing a whole screw, it might be better to remove the protruding part with a burr to prevent further irritation and soft tissue injury.

Therefore, the authors used a hybrid surgical procedure where resorbable screws, K-wires, and pins were used for reduction and fixation, followed by attachment of a metal plate to stabilize the whole bone. A 1-year follow-up showed no complications, and all cases achieved bony union. Generally, there are difficulties in fixing a resorbable screw when using a C-arm image intensifier because they are radiolucent. However, open reduction allows screw visualization and decreases difficulty fixing the screw. Additionally, because the resorbable screw was not visible in the C-arm image intensifier, it did not cover the fracture line and allowed a more accurate reduction procedure. Since the screw and wire were inserted along the guide, it was easy to confirm their trajectory.

Though the resorbable K-wire and pin do not produce specific complications, they are much weaker than the traditional K-wire and must be manipulated with caution. Additionally, because the resorbable materials are made of magnesium, their absorption produces CO₂ gas, which can be visible in follow-up radiologic imaging; however, this eventually is naturally absorbed by the body and shows no persisting complications. The resorbable K-wire and pin start to be absorbed at about 6 months and are completely resorbed by about 1 year and 6 months, though this differs by patient. This should be sufficient time to ensure bone union.

Additionally, at post-surgery follow-up, the resorbable screw,
K-wire, and pin are radiolucent, allowing easy visualization of fractural displacement or fixation complication. If displacement is noted on follow-up X-ray, screw breakage and pull out should be assessed by computed tomography and magnetic resonance imaging. When removing regular metal screws, K-wires, and pins, the callus formed over the top of regular metals need to be removed, which is much more difficult than natural absorption during bone union. As a result, only the metal plate and its screws need to be removed, a much simpler process.

Use of resorbable material showed successful bone union, and follow-up studies have shown no allergic reactions and no additional complications. Furthermore, there were no cases of metal failure, bone nonunion, infection, and anchylosis. Hybrid fixation using resorbable screws, K-wires, and pins for minor fixation and a metal plate for whole-bone fixation allows for effective anatomical reduction of Robinson type 2B clavicle fracture. Furthermore, the metal plate allows stable clavicle fixation, and the resorbable materials impart minimal risk of refracture. Therefore, use of this hybrid fixation technique may be effective in treating these types of fractures.

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INTRODUCTION

Calcific tendinitis of the shoulder, classified as enthesopathy, is a self-limiting disease characterized by the deposition of calcium phosphate crystals in the rotator cuff tendons. It most commonly occurs between the ages of 30 and 50 and is rare in those older than 70 years. It is approximately twice as likely to occur in women as in men, is more common in the right shoulder than in the left, and involves both shoulders in 10% of patients [1]. The most common site of occurrence is 1.5–2 cm away from the supraspinatus tendon insertion site on the greater tuberosity. According to the literature, calcific tendinitis occurs more frequently in some tendons than in others, occurring most often in the supraspinatus tendon. A previous study reported that 63% of cases occur in the supraspinatus tendon, 20% in both the supraspinatus and subscapularis tendons, 7% in both the infraspinatus tendon and subacromial bursa, and 3% in the subscapularis tendon [2].

Diabetes and gout are considered to be risk factors for calcific tendinitis; however, that possibility has not been fully elucidated. Many patients with calcific tendinitis also have endocrine diseases, and conservative treatment is likely to fail in such cases. In addition, stiffness of the shoulder joint, such as frozen shoulder, can occur as a result of chronic shoulder pain. A rotator cuff tear is also present in approximately 25% of patients with calcific tendinitis, though such tears tend to be more associated with small calcific deposits than with large calcific deposits [3]. The management of calcific tendinitis varies, and whether a patient has pain is an important factor. Treatment options include conservative treatment and surgical intervention, and both options are effective when carried out in the appropriate conditions. This arti-
icle is intended to help clinicians choose the appropriate treatment options for patients with calcific tendinitis.

ETIOLOGY

The etiology of calcific tendinitis of the shoulder remains controversial between two theories: degenerative calcification and reactive calcification. The theory of degenerative calcification was proposed by Codman and Akerson [4] in 1931. It posits that degenerative changes of the tendon accumulate with age, leading to decreased distribution of blood vessels and reduced local oxygenation of the tissue, which in turn produces hypoxia, thinning and tearing of the tendon, necrosis, and eventually calcification. However, that theory cannot explain why calcific tendinitis has a peak incidence in patients aged 50 years or why it is a self-limiting disease. In 1997, Uthhoff and Loehr [5] proposed the theory of reactive calcification, a series of processes that occur in precalcific, calcific, and postcalcific stages. Among them, the calcific stage consists of formative, resting, and resorptive phases. In the precalcific stage, tenocytes change into chondrocytes, a process called metaplasia, and fibrocartilaginous transformation occurs within the tendon. In the formative phase of the calcific stage, calcium deposits form and increase in size. Calcium deposition then stops at the resting phase of the calcific stage. During the resorptive phase of the calcific stage, calcific deposits are absorbed by cell-mediated phagocytosis, which is performed by cells such as macrophages and giant cells. Acute pain is mainly present in this phase. In the postcalcific stage, the spaces remaining in the tissue where calcium deposits were absorbed is replaced by granular tissue, and remodeling occurs. Calcific tendinitis eventually progresses to bursitis and inflammatory synovitis caused by chemical irritation due to the calcific deposits. Chemical furuncles are formed by swelling and increased local pressure in the tissue. Thickening of the bursa causes collisions in the subacromial space. All of these processes produce various forms of shoulder pain.

CLASSIFICATIONS

Calcific tendinitis is classified as acute (within 2 weeks), subacute (3 to 8 weeks), and chronic (more than 3 weeks), according to the duration of clinical symptoms [1]. Depending on the degree of invasion, calcium deposits are classified as localized or diffused. The diffused form is usually more painful and persists for a longer time than the localized form. Idiopathic calcific tendinitis, type I, is not accompanied by endocrine disease, whereas secondary calcific tendinitis, type II, is accompanied by endocrine diseases such as diabetes. Patients with secondary calcific tendinitis often do not respond to conservative treatment, and they require surgical treatment more commonly than patients with idiopathic calcific tendinitis. Bosworth [6] classified calcific tendinitis based on the size of calcium deposits, with small deposits being less than 0.5 cm, medium deposits being 0.5–1.5 cm, and large deposits being > 1.5 cm.

Neer [7] classified four types of calcific tendinitis based on pain and calcium deposits. Their first type is characterized by pain caused by chemical irritation as a result of the calcium deposits. The second type involves pain caused by increased local pressure within the tissue as it swells. The third type causes impingement-like pain through bursal thickening and irritation by prominent calcium deposits. The fourth type reflects pain caused by chronic stiffness of the glenohumeral joint, such as frozen shoulder.

Many classifications have been attempted based on the morphology of the calcific deposits as observed in simple radiography. In 1961, DePalma and Kruper [1] classified two types of calcium deposits on radiography. Type 1 has a fluffy shape with an ill-defined margin and mainly appears in the resorptive phase of the calcific stage, in which patients complain of acute pain. This disease state is acute calcific tendinitis. Type 2 has homogenously dense calcium deposits with a well-defined margin, and most patients with this type have little or no pain. These deposits appear in the formative or resting phase of the calcific stage, and they reflect subacute or chronic calcific tendinitis.

The French Arthroscopic Society classification divides calcific tendinitis into four types based on the morphology of calcium deposits on radiology [8]. Type A calcium deposits show dense, homogenous, and sharp contours; type B deposits show dense, segmented, and sharp contours; type C shows heterogeneous and soft contours; and type D shows dystrophic calcification at the insertion of the rotator cuff tendon. Loew et al. [9] classified three types of calcific tendinitis based on the pattern of calcium deposits observed on magnetic resonance imaging (MRI). Type A appears as a dense, uniform, and well-defined single deposit; type B is uniform and well-defined with two or more deposits; and type C appears as heterogeneous, widely spread, and ill-defined deposits.

CLINICAL EVALUATION

Calcific tendinitis is diagnosed through patient history, physical examination, and imaging examination. Among patients with calcific tendinitis, 2.7%–20% are asymptomatic, and 35%–45% of patients whose calcific deposits are discovered inadvertently on
simple radiographs develop symptoms [10,11]. The formative phase generally does not show clinical symptoms and is therefore often found by chance, although chronic intermittent pain is occasionally observed. Chronic pain occurs during shoulder forward flexion. In the resorptive phase, severe acute pain mainly occurs suddenly and worsens at night. Patients experience difficulties in lying on the affected side, and shoulder joint movement becomes limited. Patients consciously maintain a posture with internal rotation of the shoulder to relieve pain, and prior to diagnosis, most patients visit an emergency room due to the sudden onset of symptoms and pain. In addition, calcific tendinitis can be accompanied by local heat, redness, and oppressive pain. Therefore, it needs to be differentiated from septic arthritis, which presents with similar symptoms.

Simple radiographic images of the shoulder anteroposterior view, internal and external rotation views, supraspinatus outlet views, and axillary views should be acquired to determine the location of calcific deposits and predict the possibility of collision symptoms. If follow-up images are acquired, changes in the disease stage can be assessed. In general, the size of the calcific deposits does not change significantly over time, although a previous study reported that 18% of patients experienced an increase in the size of calcific deposits after follow-up for an average of 16 months [12]. According to the classification of Depalma and Kruper [1], radiological findings that show a type 1 pattern, with unclear margins and a fluffy or fleecy appearance, can be judged to be in the resorptive phase in which patients complain of acute pain. On the other hand, if a type 2 pattern with a clear margin and uniform density of calcific deposits is shown, most patients will report little or no pain because they are in the formative or resting phase.

In addition to simple radiographs, ultrasonography can be used to assess calcific deposits. It shows hyperechoic areas and an obvious posterior acoustic shadow in the formative or resting phase. In the resorptive phase, on the other hand, hyperechoic areas are relatively reduced, and the posterior acoustic shadow is also reduced or not observed. MRI is not a routine evaluation; however, it is helpful in identifying lesions in the shoulder joint, including the location of calcific deposits and the condition of the rotator cuff. In T1-weighted images, calcific deposits show a low signal intensity, whereas in T2-weighted images, the edema pattern surrounding the calcific deposits can show a high signal intensity.

Generally, calcific deposits appear to have a fluffy shape on radiography and a toothpaste-like appearance on arthroscopic findings in the resorptive phase of calcific tendinitis, whereas they appear homogeneously dense on radiography and have a chalk-like appearance on arthroscopic findings in the formative or resting phase of calcific tendinitis (Fig. 1).

**TREATMENTS**

**Conservative Treatment**

The primary treatment for calcific tendinitis is conservative, and it has a success rate of 30% to 80%. Non-steroidal anti-inflammatory analgesics are used to relieve acute pain, and the affected shoulder joint needs to be rested using an arm sling. When there are signs of collision or the patient is in the resorptive phase, subacromial steroid injections are effective in alleviating pain. The ultrasound-guided barbotage technique can relieve pain with decompression effects by aspirating and washing out calcific deposits using an 18-gauge or 22-gauge needle. A 3–5-mL mixed solution of normal saline and lidocaine can be administered to locations with calcific deposits, and the aspiration can be repeated until the deposits are washed away. Afterward, an injection of an additional 1 mL of steroid and 2 mL of lidocaine into the bursa around the calcific deposits can enhance pain relief. A previous study reported that the ultrasound-guided barbotage technique

![Fig. 1. Radiographic and arthroscopic findings of resorptive and formative or resting phase of calcific tendinitis. (A) In the resorptive phase of calcific deposits (arrows) appear fluffy-like shape on shoulder anteroposterior (AP) view and (B) toothpaste-like appearance on macroscopic findings observed by arthroscopy. (C) In the formative or resting phase of calcific deposits (arrow) appear homogeneously dense on shoulder AP view and (D) chalk-like appearance on macroscopic findings observed by arthroscopy.](https://doi.org/10.5397/cise.2020.00318)
achieved satisfactory results in 70% of patients [13]. It can also be performed under fluoroscopy. When performing the barbotage technique, anesthetics and steroids can be injected into the deposition sites and the subacromial space to enhance the effect of the technique.

A randomized controlled study found that ultrasound therapy improved quality of life and helped relieve pain [14]. The study was conducted at a 0.89 MHz frequency and 2.5 W/cm² intensity for 15 minutes per session. The first 15 treatments were performed five times per week for a total of 3 weeks. The remaining nine treatments were performed three times per week for a total of 3 weeks. Furthermore, steroidal and nonsteroidal anti-inflammatory analgesic were not administered during the study. Ultrasound therapy show effects similar to those of surgery.

Extracorporeal shock wave therapy (ESWT) is also widely used and is one of the most effective treatments for pain relief. A prospective study showed that high-energy ESWT in chronic calcific tendinitis patients had a high treatment success rate and few side effects, however, 20% of the patients underwent surgical treatment due to treatment failure during 4 years [15].

In another study, surgical treatment was more effective than ESWT for homogeneous calcification; however, in heterogeneous calcification, ESWT and surgical treatment showed similar effects [11]. During the 1-year follow-up after ESWT in that study, calcific deposits were not observed in 47% of patients, were resorbed in 33% of patients, and showed no changes in 20% of patients [11]. Thus, ESWT is a treatment that can be performed before surgical treatment. Other studies have also reported ESWT as a successful treatment [16,17].

In sum, various conservative treatment options (ultrasound-guided barbotage and injection, ultrasound therapy, and ESWT) show effects similar to those with surgical treatment and are noninvasive. Therefore, conservative treatment is recommended before surgical treatment. Patients with acute pain should begin passive exercise of the shoulder joint to restore range of motion (ROM) after managing the pain with conservative therapy for 1 to 2 weeks and continue until they experience pain relief. In most patients with chronic pain, the ROM of the shoulder joint is close to the normal range. Thus, strengthening exercises need to be started within the range that is comfortable for the patient. If stiffness is observed in patients with chronic calcific tendinitis, adhesive capsulitis should be ruled out. Pain should be controlled first, followed by passive ROM exercises and pendulum exercises.

Surgical Treatment
When conservative treatment does not improve pain, shoulder function can decline, making daily activities difficult to perform. For patients who do not respond to conservative treatment after 6 months, surgery should be considered. One study reported that surgery was performed due to conservative treatment failure in approximately 10% of patients, and it showed the best effects in patients with chronic calcific tendinitis in whom the onset of symptoms was more than a year prior to surgery [18].

In general, acute calcific tendinitis responds well to conservative treatment. However, chronic calcific tendinitis often requires surgical treatment, which can take the form of open surgery or arthroscopic surgery. Both surgical methods remove calcific deposits and have shown satisfactory clinical outcomes. Between them, arthroscopic surgery has the advantages of a short rehabilitation period and cosmetic superiority, and it is a less invasive method that helps protect surrounding tissues and can be used to treat comorbidities such as frozen shoulder and rotator cuff tears. Previous studies have reported no significant differences in the clinical outcomes after complete and incomplete removal of calcific deposits [19]. Other studies reported that patients whose radiographic findings after surgery indicated a removal or reduction of calcific deposits showed better prognoses than those whose calcific deposits remained unchanged [20]. This suggests that it is essential to remove as many calcific deposits as possible while minimizing damage to the rotator cuff. If signs of collision are observed, an acromioplasty procedure is effective.

Whether rotator cuff repair after the removal of calcific deposits affects clinical outcomes remains controversial. In general, patients with rotator cuff repair do not show different clinical results from patients who do not receive such a repair, and further progression of a rotator cuff tear is rarely observed. However, several authors have suggested that rotator cuff repair can facilitate rehabilitation treatment in patients with a combined full-thickness rotator cuff tear [21]. In addition, one study reported that clinical outcomes were satisfactory when using both side-side sutures and suture anchors for rotator cuff tears [22].

SURGICAL TECHNIQUES

Glenohumeral Joint
A posterior portal is made 2 cm inferior and 1 cm medial to the posterolateral corner of the acromion. After inserting the arthroscope into the joint, an anterior portal is made lateral to the coracoid process and anterior to the acromioclavicular joint. When frozen shoulder is present, arthroscopic capsular release should be performed. Expansion, swelling, or fibrillation of the articular side of a supraspinatus tendon that could have calcific deposits needs to be assessed in detail. If a suspicious area on the joint surface is observed, an 18-gauge spinal needle is passed

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through the supraspinatus tendon at the lesion site 1 cm outside the acromion and placed behind the long head of the bicep tendon. Polydioxanone (PDS) can then be passed through the needle to the supraspinatus tendon for marking, and the spinal needle can be removed while maintaining the PDS at its location. This helps locate calcific deposits in the subacromial space.

Subacromial Space
After the appropriate glenohumeral joint exploration, an arthroscope moves into the subacromial space. Arthroscopic treatment of calcific tendinitis is mostly performed in the subacromial space. In general, moderate inflammatory changes, as well as hyperproliferation and thickening of the bursa, can be observed. Afterward, a lateral working portal is made at the anterolateral area of the acromion.

Bursectomy and Decompression
If PDS marking was performed to visualize a lesion in the articular joint, decompression is conducted by thoroughly removing the bursa using a shaver with a suction opening through the lateral working portal. The PDS should not be cut during the bursectomy. If no lesion is visible in the articular joint or if calcific deposits are located on the bursal side, comprehensive bursectomy is performed first. Adequate hemostasis using electrocautery is required to obtain a proper surgical field. Edema and swelling can be seen macroscopically in areas with calcific deposits, which helps to find them.

Calcific Deposit Removal
After identifying the location of calcium deposits, PDS and the needle used for marking are removed. In the acute or resorptive phases, calcific deposits have a toothpaste-like appearance. In the chronic or formative phases, they have a chalk-like appearance. The deposits can be visually identified using an arthroscope (a 16-gauge needle is most often used). When needling is performed in an area with calcific deposits, calcific deposits can be observed as creamy or snowy. If the deposits are large or if there are difficulties removing them, a small incision can be made in the long axis of the tendon using a scalpel. A probe can be used to remove residual calcific deposits in the tendons. It is unnecessary to completely remove the calcific deposits, which could damage the tendon, because the effect of decompression is more important than complete removal of the calcific deposits. After removing the calcific deposits in the tendon, debridement of the surrounding tissue and removal of floating residual calcific deposits is performed using a shaver.

Rotator Cuff Tendon Repair and Acromioplasty
Whether the empty space in the tendon left by removing calcific deposits needs to be repaired is controversial. If the rotator cuff tear is small, repair is not needed. However, if the tear is 2 cm or larger and involves more than 70% of the thickness of the tendon, tendon repair is performed. Torn areas near the supraspinatus tendon insertion are generally repaired using suture anchors. If the tear is located within the musculotendinous junction, side-to-side suturing using PDS is performed with a suture lasso (Fig. 2). If the tear is large, rotator cuff repair using suture anchors is necessary (Fig. 3). However, repair should be performed carefully. Calcific tendinitis is a self-limiting disease, and thus repair can increase the pressure at the removal site. In a study by Lee and Shin [23], approximately 26.5% of patients required rotator cuff repair after arthroscopic removal of calcific deposits, and they found no clinical differences between patients who received rotator cuff repair and those who received simple decompression. Acromioplasty is not required in all patients with calcific tendinitis. In patients with impingement syndrome or obvious osteophytes in the acro-

Fig. 2. Arthroscopic decompression and rotator cuff repair using side-to-side sutures. (A) Preoperative fat suppressed T2-weighted magnetic resonance imaging coronal view shows calcific deposits on the supraspinatus tendon within musculotendinous junction. (B) Arthroscopic findings after removal and debridement of calcific deposits lesion and an approximately 1.0×1.0-cm-sized defect is seen. (C) Arthroscopic side-to-side suture is performed using polydioxanone.
mion, acromioplasty is effective and widens the subacromial space to prevent collisions.

**AUTHORS’ PREFERRED TREATMENTS**

In some patients, it is difficult to identify the location of calcific deposits, even when the bursa has been sufficiently removed. In such patients, calcific deposits can be located by gently needling the rotator cuff tendon at suspicious areas with a 16-gauge spinal needle (after removing the stylet) and assessing the presence of calcific deposits on the needle tip. When the needle passes through calcific deposits, leaking of the calcific deposits into the subacromial space can be observed.

After removing calcific deposits, large partial or small full-thickness rotator cuff tears are not repaired. Rotator cuff repair is performed only for medium or large full-thickness rotator cuff tears. Side-to-side sutures are placed using PDS for tears at the musculotendinous junction. For other types of tears, rotator cuff repair is performed according to the shape of the tear using suture anchors.

**POSTOPERATIVE REHABILITATION**

Shoulder and elbow motion are allowed immediately after the operation as long as the pain is tolerable, and an arm sling is required for 3 weeks for protection in patients with calcific decompression. Passive and active shoulder ROM exercises should be started immediately, and muscle strengthening exercises should be started 6 to 12 weeks after the operation. Patients can immediately perform light office work, and moderate labor can be started from 6 to 12 weeks after the operation.

If the rotator cuff was repaired using a suture anchor at the tendon insertion site, a shoulder abduction brace needs to be used for 4 weeks, and gradual passive shoulder ROM exercises need to be started immediately after the operation. Muscle strengthening exercises can be started from 6 to 12 weeks after the operation, depending on the size of the tear.

**CONCLUSION**

The primary choice of treatment for calcific tendinitis is conservative, especially in patients with acute calcific tendinitis. However, conservative treatment often fails in chronic patients, so surgical treatment is required. Many patients regard operative treatment as a simple procedure and expect rapid recovery. However, the clinical symptoms of many patients do not improve immediately after surgery and require 6 months or more for complete recovery. Therefore, patients should be given sufficient prior explanation that recovery could be delayed and that intermittent pain could occur for 2 years or more after surgery. In addition, continual follow-up for pain control and recurrence of symptoms is necessary after surgery.

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1. AIMS AND SCOPE

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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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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/ictrp/en, and http://clinicaltrials.gov.

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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 a 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).

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,
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 (a, b, …) or asterisks (*). Explanation for superscript citation should be done as following examples: a) 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 be 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 ICMJE Recommendations (https://www.nlm.nih.gov/bsd/uniform_requirements.html).

• Examples of references are as follows:

Journal article


Book & book chapter


Website

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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Gallery Proof
The author(s) will receive the final version of the manuscript as a PDF file. Upon receipt, the author(s) must notify the editorial office (or printing office) of any errors found in the file within two days. Any errors found after this time are the responsibility of the author(s) and will have to be corrected as an erratum.

Errata and Corrigenda
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

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☐ 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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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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