J Shoulder Elbow Surg (2019) 28, 1998–2006

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ELBOW

Surgical outcomes for post-traumatic stiffness after elbow fracture: comparison between open and arthroscopic procedures for intra- and extra-articular elbow fractures

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Hypothesis: We hypothesized that arthroscopic osteocapsular arthroplasty has a comparable outcome to that of the corresponding open procedure.
Methods: Patients treated with osteocapsular arthroplasty for post-traumatic stiffness were assigned to open procedure (OPEN) and arthroscopic procedure (ARTHRO) groups. The clinical outcomes were measured based on range of motion (ROM), Mayo Elbow Performance Score (MEPS), and visual analog scale (VAS) score. Based on the initial trauma, the patients were grouped into either intra-articular fracture (I) or extra-articular fracture (E) groups, followed by comparison of the 2 groups.
Results: The overall, ROM, VAS, and MEPS scores showed improvement in both groups. Preoperative VAS scores improved from 6.6 ± 1.4 to 2.2 ± 0.9 following OPEN and from 6.5 ± 1.2 to 2.1 ± 1.0 following ARTHRO. Preoperative flexion improved from 88° ± 14° to 113° ± 17° following OPEN and from 102° ± 15° to 122° ± 8° following ARTHRO. Preoperative extension improved from 36° ± 14° to 17° ± 12° following OPEN and from 30° ± 8° to 15° ± 7.4° following ARTHRO. Preoperative MEPS improved from 48.9 ± 11.5 to 80.0 ± 14.8 following OPEN and from 52.3 ± 12.2 to 80.8 ± 7.9 following ARTHRO. All values for the clinical outcomes were worse in group I than in group E.
Conclusions: Arthroscopic osteocapsular arthroplasty is comparable to the corresponding open procedure with regard to the use of our indications. The clinical outcomes in the intra-articular fracture group as a previous trauma were worse than those in the extra-articular fracture group.
Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Post-traumatic stiff elbow; osteocapsular arthroplasty; elbow fracture; arthroscopy; elbow stiffness; arthrolysis; debridement arthroplasty

Institutional Review Board approval was received from Asan Medical Center (AMC IRB 2017-1221).

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1058-2746/$ - see front matter
https://doi.org/10.1016/j.jse.2019.06.008

Post-traumatic elbow stiffness can occur as a result of extrinsic or intrinsic causes. Intrinsic stiffness occurs as a result of intra-articular injuries, whereas extrinsic stiffness is primarily associated with contracture of extra-articular soft tissue structures.

Surgical release for post-traumatic stiffness was initially performed in an open manner and comprised capsular release, synovectomy, and removal of osteophytes, heterotropic ossification (HO), and loose bodies to reduce the mechanical symptoms, thereby improving the range of motion (ROM).[9,28,29] This surgical procedure was performed to relieve pain related to impingement as well as to recover the functional ROM.[16,23] Past studies have reported a favorable outcome with a low complication rate.[4,20] With advances in minimally invasive surgical techniques and innovations, the arthroscopic approach has emerged as an attractive option for both mechanical impingement due to osteophytes and loose bodies and soft tissue contractures.[1,10,22,23] The benefit of the arthroscopic approach is minimal surgical damage, which promotes rapid rehabilitation.[1,15] Although several studies have reported the outcomes of arthroscopic osteocapsular arthroplasty,[19,31] to our knowledge, no published studies have compared the open and arthroscopic procedures. Therefore, we compared the clinical outcomes following open and arthroscopic osteocapsular arthroplasty for post-traumatic elbow stiffness. We hypothesized that arthroscopic osteocapsular arthroplasty has a comparable outcome to that of the open procedure.

Materials and methods

Data of all patients who underwent primary elbow osteocapsular arthroplasty for post-traumatic stiffness between January 2010 and December 2015 at a tertiary university hospital were retrieved from the medical records and radiographic archives and retrospectively reviewed by 2 orthopedic surgeons (J.-M. K., E. K.) with a blinded control. After the review of medical records from the database, 72 cases were collected. The inclusion criteria were (1) age 20-50 years, (2) documented post-traumatic stiffness after elbow fracture caused by previous trauma, (3) arthroscopic or open osteocapsular arthroplasty, and (4) availability of medical information for >2 years of follow-up, including adequate radiographs with both plain radiograph and computed tomography. We excluded 28 patients with (1) post-traumatic, degenerative, or rheumatoid arthritis in the advanced stage, which were the indication of total elbow arthroplasty (n = 6), (2) osteocapsular arthroplasty as a revision surgery (n = 2), (3) improper radiography (n = 5), (4) inadequate or loss of follow-up (n = 11), and (5) simple dislocation without fracture caused by previous trauma (n = 4) (Fig. 1). And there was no central nervous system or burn injury in previous trauma. The indications for an arthroscopic procedure included (1) failure of at least 6 months of conservative treatment, (2) no combined ulnar neuropathy proven by electromyography and nerve conduction velocity, (3) no high-grade flexion limitation (<90°) that could induce stretch injury of the ulnar nerve after surgery, and (4) no severe skin contracture or wound problem that could affect the neurovascular structures or require flap surgery. Demographic characteristics are given in Table I. Distal humerus fracture in 7 (2 for 13B type and 5 for 13C type in AO classification), terrible triad in 7, olecranon fracture in 4, and radial head fracture in 4 were included as the intra-articular fracture group. Distal humerus fracture in 12 (13A in AO classification), radial neck fracture in 6, and proximal ulnar fracture in 4 comprised the extra-articular group. Visual analog scale (VAS) was used to assess and monitor the pain, and a goniometer was used to measure the range of motion (ROM) by physician assistant preoperatively and postoperatively. Preoperative data included age, sex, pain score (VAS), ROM arc, Mayo Elbow Performance Score (MEPS), and assessment for ulnar neuropathy.[3] Dellon classification for evaluation of the ulnar nerve neuropathy was used preoperatively. Mild in 3, moderate in 5, and severe in 2 were included. Postoperatively, we evaluated the clinical outcomes using the MEPS, VAS, and ROM scores in addition to the radiologic outcomes. The correlations between each stage and clinical scores and assessments (ROM, VAS, and MEPS) were evaluated. All patients were operated by the same senior surgeon. All evaluations were assessed by 2 independent orthopedic surgeons who did not perform the surgery. If the patient had ulnar neuropathy or high-grade flexion limitation of <90°, subcutaneous ulnar nerve anterior transposition was performed after implant removal. Radiologic evaluation of recurrence or new development of osteophytes, loose bodies, and HO was performed at the final follow-up using plain radiographs as compared with that using postoperative plain radiographs with the Hastings classification system of elbow ectopic bone formation. There are 3 groups or classes based on functional range of motion. Class I includes patients with positive radiographs for heterotopic ossification, but no functional limitations. Class II radiographs demonstrate heterotopic ossification, and there is a functional limitation—either in the flexion/extension axis (class IIA), the pronation/supination axis (class IIB), or both (class IIC). Class III patients have ectopic bone with ankylosis either in flexion/extension (class IIIA), pronation/supination (class IIIB), or both (class IIIC).[8] The patients were divided into the intra-articular fracture (group I) and extra-articular fracture (group E) groups, and the outcomes were compared.

Surgical technique

Open osteocapsular arthroplasty

Open osteocapsular arthroplasty was performed via a medial approach.[10,28,29] Ulnar nerve anterior transposition was achieved via the same approach in patients with preoperative ulnar neuropathy or flexion of <90°. When using the lateral (Kocher) approach, it was possible to approach the anterior and posterior capsules in the column procedure after the lateral supracondylar ridge was detected. If the lateral implant needed to be removed and there was no ulnar nerve pathology with moderate stiffness, a lateral approach was used. A posterior approach was rarely used, and only in cases where the implant for olecranon fracture needs to be removed from posterior side.

Anterior compartment

The origin of the flexor-pronator muscle group was elevated from the medial epicondyle. All anterior structures in the distal humeral region were elevated subperiosteally. The anterior band of the medial collateral ligament was preserved. The

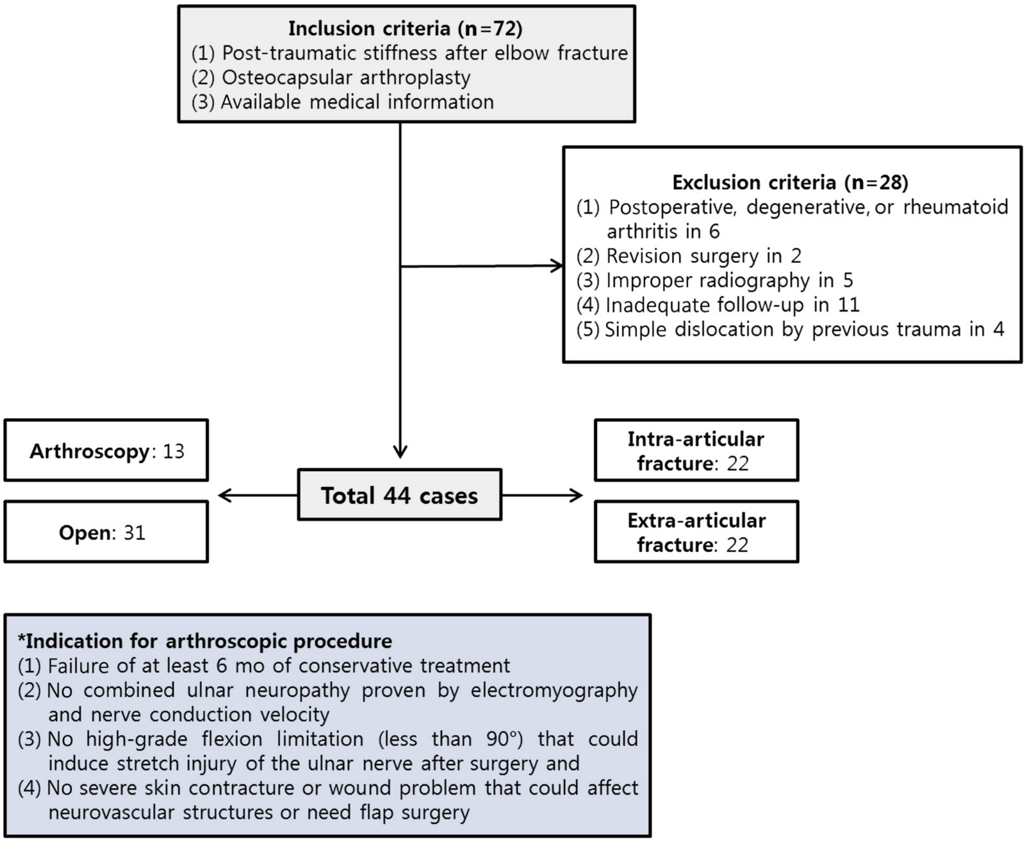

Figure 1 Study design and indications for arthroscopic procedure.

Table I Patient demographic characteristics depending on the open and arthroscopic osteocapsular arthroplasty procedures

Preoperative value	OPEN	ARTHRO	*P* value
Cases, no.	31	13	—
Age, yr	39.8 ± 13.1	39.0 ± 16.2	.98
Sex, male/female, n	19/12	11/2	.17
Follow-up period, mo	32.7 ± 14.4	26.5 ± 14.2	<.01
Preoperative VAS score	6.6 ± 1.4	6.5 ± 1.2	.86
Extension, °	36 ± 14	30 ± 8	.09
Flexion, °	88 ± 14	102 ± 15	.009
MEPS, average	48.9 ± 11.5	52.3 ± 12.2	.40
Ulnar nerve neuropathy, n (%)	10 (32.2)	0	<.01

VAS, visual analog scale; *MEPS*, Mayo Elbow Performance Score; *OPEN*, open capsular arthroplasty group; *ARTHRO*, arthroscopic osteocapsular arthroplasty group.
Unless otherwise stated, values are mean ± standard deviation.

flexor-pronator origin and the anterior capsule were dissected down to the bone level. Osteophytes and loose bodies were removed from the coronoid process, the coronoid fossa, and the radial fossa using a rongeur or an osteotome. It is important to resect osteophytes from the medial edge of the coronoid meticulously, without disturbing the continuity of the anterior oblique bundle. To facilitate visualization of this area, a small narrow retractor is inserted to pull the anterior oblique bundle medially. This allows for visualization of the osteophytes and affords protection of the bundle.[29] The combined rotational stiffness was managed with routine open débridement, including the bony spur or HO resection, annular ligament release from radial head, and capsulectomy.

Posterior compartment

The ulnar nerve was fully mobilized to allow its transposition anteriorly. The medial joint line was exposed to the anterior band, and the posterior band of the medial collateral ligament was excised. Next, the posterior capsule was excised by elevating the triceps using a deep retractor.

Lateral compartment

The lateral compartment was exposed through a lateral skin incision that extended distally from the lateral supracondylar ridge of the humerus to the posterior border of the ulna. Dissection between the triceps and the brachioradialis muscles exposed the lateral condyle and joint capsule. Dissection through the radial edge of the anconeus muscle allowed the exposure of the radial head by incising the annular ligament longitudinally. The anterior joint capsule was dissected subperiosteally. Spurs were removed from the radial head, the radial fossa, and the posterior edge of the capitellum.

Arthroscopic osteocapsular arthroplasty

The patient was positioned in lateral decubitus under general anesthesia. The elbows were set to allow full assessment for postoperative flexion and extension. Using an 18-G needle, normal saline was injected into the joints through the ‘‘soft spot’’ (ie, the site of midlateral portal), located at the center of a triangle formed by the lateral epicondyle, radial head, and olecranon process. Once the joint was distended, we first established a proximal anteromedial portal. This was typically 2 cm proximal to the medial epicondyle and 1-2 cm anterior to the medial intermuscular septum. In a typical elbow, 20-30 mL of normal saline seemed to adequately distend the joint. However, capsular compliance in stiff elbows was only 15% that of a normal elbow, which significantly decreased the joint space volume and increased the risk for injury to the neurovascular structures.[6] Moreover, it is usually difficult to observe the radial capitellar joint directly because of severe intra-articular adhesions. Careful shaving is performed from the lateral epicondyle to obtain an intra-articular view of the radiocapitellar joint. This portal is used for intra-articular retractor after intra-articular adhesion. Standard elbow arthroscopy portals (ie, proximal anteromedial, anterolateral, direct posterior, and posterolateral) and an accessory portal for an intra-articular retractor were used. Anterior capsulectomy was performed with an arthroscopic shaver. The direct posterior portal was used along with the posterolateral portal to remove loose bodies at the olecranon fossa and at the tip of the olecranon. Both the posteromedial and posterolateral gutters were also débrided. Posterior capsulotomy was considered in patients in whom satisfactory flexion could not be achieved by the anterior compartment procedure.

Postoperative management

Every patient achieved the goal of the ROM recovery intraoperatively, which is functional range of motion (ie, at least 30°-130° extension-flexion and 50° of pronation-supination). Soft compressive dressings and an anterior splint were applied for all patients. Neurologic examination was performed by the surgeon after the patients recovered from anesthesia. After confirming an intact neurologic examination, the elbows were placed in extension and supination for 24 hours. From postoperative day 1, immediate motion was encouraged as per clinic physician instruction. With assistance from the other hand, the patient could increase the ROM in both extension and flexion, with nighttime splinting for the first 3-4 weeks.

Statistical analysis

All statistical analyses, including a priori power analysis, were conducted using SPSS (version 22.0; IBM, Armonk, NY, USA). A power of 81% was calculated under the assumption that true effect size was 0.6 in a total of 44 patients. The Kolmogorov-Smirnov normality test was conducted for continuous variables to evaluate the distribution of data composition. The Wilcoxon test was conducted to analyze the variables. All statistical tests were 2-sided, with a significance level of .05. A correlation coefficient of <0.3 was considered to be low, 0.3-0.6 to be moderate, and >0.6 to be high. The null hypothesis of no difference was rejected at P <.05.

Results

Overall results and correlation with symptom duration

The overall ROM–flexion (92° ± 15° to 116° ± 15°, P < .01), ROM–extension (34° ± 12° to 16° ± 10°, P < .01), MEPS (49.8 ± 11.6 to 80.2 ± 13.7, P < .01), and VAS scores (6.6 ± 1.3 to 2.2 ± 0.9, P < .01) were improved from preoperation to final follow-up. Complication was noted, including wound problems, which was managed with conservative treatment in 3, and ulnar nerve irritation or neuropathy in 7, which were classified using the Dellon classification as mild. Symptom duration from the day the symptoms began to the time of first visit to the hospital showed a moderate correlation with ROM and VAS scores, whereas it showed a high correlation with MEPS (Table V).

Arthroscopic vs. open procedure

Of the 44 patients enrolled in the study, 13 belonged to the arthroscopic osteocapsular arthroplasty (ARTHRO) group and 31 to the open capsular arthroplasty (OPEN) group. The mean total follow-up duration was 32.7 (range: 27-33) and 26.5 (range: 25-28) months following OPEN and ARTHRO, respectively. The average ages of the patients were 39.8 ± 13.1 (range: 31-49) and 39.0 ± 16.2 (range: 26-50) years in the OPEN and ARTHRO groups, respectively. Preoperative VAS scores improved from 6.6 ± 1.4 to 2.2 ± 0.9 following OPEN and from 6.5 ± 1.2 to 2.1 ± 1.0 following ARTHRO. Preoperative ROM–flexion improved from 88° ± 14° to 113° ± 17° following OPEN and from 102° ± 15° to 122° ± 8° following ARTHRO. Preoperative ROM–extension improved from 36° ± 14° to 17° ± 12° following OPEN and from 30° ± 8° to 15° ± 7.4° following ARTHRO. Preoperative MEPS improved from 48.9 ± 11.5 to 80.0 ± 14.8 following OPEN and from 52.3 ± 12.2 to 80.8 ± 7.9 following ARTHRO (Tables I and II). No significant difference, except for the degree of flexion (P < .01), was noted in postoperative ROM between 2 groups. However, the difference between preoperative

Table II Comparison of postoperative values between the open and arthroscopic osteocapsular arthroplasty procedures

Postoperative value	OPEN	ARTHRO	*P* value
Cases, n	31	13	—
VAS score	2.2 ± 0.9	2.1 ± 1.0	.90
Extension, °	17 ± 12	15 ± 7	.42
Extension improvement, °	18 ± 8	15 ± 13	.48
Flexion, °	113 ± 17	122 ± 8	.03*
Flexion improvement, °	25 ± 22	19 ± 11	.30
MEPS	80.0 ± 14.8	80.8 ± 7.9	.82
Heterotrophic ossification, n (%)	4 (13)	1 (7.5)	.16
Ulnar nerve neuropathy, n (%)	5 (16)	2 (15)	.56

VAS, visual analog scale; *MEPS*, Mayo Elbow Performance Score; *OPEN*, open capsular arthroplasty group; *ARTHRO*, arthroscopic osteocapsular arthroplasty group .
Unless otherwise stated, values are mean ± standard deviation.
* Statistical significance.

flexion and postoperative flexion was not significant. Neurovascular complications and infections did not occur in either of the groups intraoperatively. Postoperative radiologic findings in one case (7.5%) of the ARTHRO group, which belonged to Hasting class I, included recurrence or new development of an HO at the time of final follow-up. The OPEN group also included 4 cases (13%) with new development of a spur or HO. Three cases were determined to be Hasting class I , which is the ectopic bone without functional limitation. A case in the OPEN group developed postoperative stiffness with a functional limitation of F/E (Hasting class IIA). Reoperation was performed for this case using an open procedure because of the recurrence of osteophytes and loose bodies. A revision surgery was performed in 1 patient following OPEN (3.2%), with no revision surgery after ARTHRO. Ulnar nerve neuropathy was included in 5 patients following OPEN (16%) and in 2 patients following ARTHRO (15%).

Intra- vs. extra-articular fracture caused by previous trauma

Of the 44 patients enrolled in the study, 22 showed extra-articular fractures (group E), and the remaining 22 showed intra-articular fractures caused by previous trauma (group I). The mean total follow-up duration was 29.1 (range: 25-32) and 29.8 (range: 25-33) months in the groups E and I, respectively. The average ages were 39.7 ± 15.1 and 39.9 ± 12.7 years in the groups E and I, respectively. Neurovascular complications did not occur in either of the groups intraoperatively. Postoperative ulnar nerve neuropathy was included in 3 patients following group E and in 4 patients following group I.

Extra-articular fracture group

Preoperative ROM–flexion of 95° ± 16° improved to 123° ± 15°. Preoperative ROM–extension of 35° ± 12° improved to 15° ± 12°. Preoperative MEPS of 48 ± 11 improved to 83 ± 10. Preoperative VAS scores of 6.8 ± 1.1 improved to 2.0 ± 1.1. Postoperative radiologic findings in 2 cases, identified as Hasting class I, in group E included recurrence or new development of spur or HO at the time of final follow-up.

Intra-articular fracture group

Preoperative ROM–flexion of 89° ± 14° to 109° ± 13°. Preoperative ROM–extension of 34° ± 14° to 17° ± 9°. Preoperative MEPS of 51.1 ± 12.0 to 73.6 ± 14.8. Preoperative VAS scores of 6.4 ± 1.5 to 2.4 ± 0.7. Group I also included 3 cases with recurrence or new development of spur or HO at the time of final follow-up. Two cases were determined to be Hasting class I, and 1 case developed postoperative stiffness with functional limitation of F/E (Hasting class IIA) (Tables III and IV).

Discussion

Our study showed that the clinical outcomes of osteocapsular arthroplasty were recommendable treatment options in either arthroscopic or open procedure, with different indications for each procedure. The subgroup analysis indicated that intra-articular elbow fracture caused by previous trauma resulted in worse outcomes in terms of ROM and MEPS than did the subgroup with extra-articular elbow fracture.

Surgical treatment of post-traumatic elbow stiffness is challenging and depends on the severity of the pathology.[2,7,15,18] Conventional open-débridement arthroplasty has been widely performed for treating pain and limited ROM in post-traumatic elbow stiffness when the patient does not have advanced post-traumatic arthritis. However, total elbow arthroplasty could be considered in advanced post-traumatic arthritis.[7,9,20] With advances in minimally invasive surgical techniques and equipment, the

Table III Patient demographic characteristics

Preoperative value	Extra-articular	Intra-articular	*P* value
Cases, n	22	22	—
Age, yr	39.7 ± 15.1	39.9 ± 12.7	.97
Sex, male/female, n	15/7	15/7	>.99
Follow-up period, mo	29.1 ± 4.1	29.8 ± 4.8	.62
Preoperative VAS score	6.8 ± 1.1	6.4 ± 1.5	.26
Extension, °	35.2 ± 12.0	34.0 ± 14.1	.75
Flexion, °	95.5 ± 16.5	89.8 ± 14.6	.23
MEPS	48.6 ± 11.5	51.1 ± 12.0	.49
Ulnar nerve neuropathy, n (%)	4 (18)	6 (27)	.35

VAS, visual analog scale; *MEPS*, Mayo Elbow Performance Score.
Unless otherwise stated, values are mean ± standard deviation.

Table IV Comparison of postoperative values between the extra- and intra-articular elbow fracture groups

Postoperative value	Extra-articular	Intra-articular	*P* value
VAS score	2.0 ± 0.9	2.4 ± 0.8	.22
Flexion, °	123 ± 15	109 ± 13	.003*
Extension, °	15 ± 12	17 ± 9	.64
MEPS	83.9 ± 10.2	73.6 ± 14.8	.045*
Post-traumatic arthritis, n (%)	3 (13.6)	14 (63.6)	.001*
Heterotopic ossification, n (%)	2 (9)	3 (13.6)	.52
Ulnar nerve symptom, n (%)	3 (13.6)	4 (18.2)	.72

VAS, visual analog scale; *MEPS*, Mayo Elbow Performance Score.
Unless otherwise stated, values are mean ± standard deviation.
* Statistical significance.

arthroscopic procedure has gained popularity owing to its benefits: the minimally invasive approach, effective intra-articular approach, and desirable outcome (ie, early recovery and return to work).[1,11,12,14] Nevertheless, some drawbacks regarding high technical difficulty in this technique result in a slow learning curve.[27] Arthroscopic procedure was predominantly performed in elbows with a minor restriction in ROM. According to the recent systematic review,[13] the mean preoperative ROM was 84°, compared to 52° for open arthrolysis. This reflects that the indication for arthroscopic procedure is still limited compared with the indication for open procedure because of the limited visualization especially for the extracapsular approach. Because the arthroscopic procedure basically is performed in the articular space, extra-articular HO could not be resected properly. Therefore, extra-articular pathology including extra-articular HO is an out of indication for the arthroscopic osteocapsular arthroplasty.

In our study, the mean ROM arc values at the latest follow-up were 98° and 107° following OPEN and ARTHRO, respectively. Considering the fact that functional arc of motion of >100° is required for activities of daily living,[16] open and arthroscopic osteocapsular arthroplasty effectively provided satisfactory functional outcomes in our study. The postoperative MEPS in both the groups was improved and showed no significant difference (Table II). However, the degree of flexion was inferior following OPEN in comparison to that following ARTHRO ($P = .03$). This difference may have resulted from the different indications for the 2 procedures. The indications for the open procedure included severe flexion limitation of <90° and scars requiring wound control. The flexion gain was not different between the 2 groups ($P = .26$). This result indicates that arthroscopic osteocapsular arthroplasty is as effective as the open procedure in treating stiffness of osteoarthritic elbows based on our indications. It is, however, theoretically difficult to directly compare the 2 procedures with different cohorts on the basis of previous literature. However, each procedure has been proven to significantly improve ROM and functional recovery in the past. Wada et al[28] reported the outcomes of débridement arthroplasty via a posteromedial approach with reliable long-term results for the relief of pain, gain in ROM, and ability to return to work. Overall, 85% of the outcomes were satisfactory. Willinger et al[30] also reported successful outcomes for arthroscopic arthrolysis for post-traumatic elbow stiffness. The mean arc of motion increased from 74.3° preoperatively to 120.5° postoperatively ($P < .001$), and the mean improvement was 46.3° ± 27.5°. The mean postoperative VAS score was 0.9 ± 1.5. A functional arc of elbow motion of >100° was achieved in 92.9% of the patients. The Elbow Self-Assessment Score indicated good to excellent clinical outcomes at 88.8 ± 10.0 points. Eygendaal et al[13] performed a systematic review for the outcomes of surgical treatment of post-traumatic elbow stiffness and identified 4 different treatment modalities from the included studies, namely, (1) open arthrolysis, (2) arthroscopic arthrolysis, (3) open arthrolysis with external fixation, and (4) open arthrolysis with distraction arthroplasty. The gain in ROM was 51°, 40°, 88°, and 56° for groups 1-4, respectively. The average percentage of complications was 23, 5, 73, and 58 for groups 1-4, respectively.

Second, the degree of flexion was superior following ARTHRO than following OPEN ($P = .03$). However, this result did not indicate that the arthroscopic procedure was superior because the preoperative degree of flexion was low in OPEN and the gain of arc was not different between the groups. Our arthroscopic indications for post-traumatic stiffness were extremely narrow. These are strongly correlated with the high risk of nerve injury and the limitations of the arthroscopic working portal and visualization. If any nerve problem was suspected in any case, the open procedure was selected rather than arthroscopy considering that the risk of nerve injury is relatively high during the arthroscopic procedure for stiff elbows.[14,24] Even when the scope is properly inserted in the intra-articular space, it is extremely difficult to achieve initial orientation and adequate visualization because of the severe intra-articular adhesions and the narrow joint space.[25,32] Based on this anatomic consideration (Fig. 2), a conventional anterolateral portal placement seems reasonable when created 2 cm proximal and 1 cm anterior to the lateral epicondyle, as described by Field et al.[5,26] However, in post-traumatic stiff elbow, the normal anatomic position of the nerve can be changed because of a previous surgery. Therefore, we recommend creating the first portal 2 cm proximal and immediately anterior to the lateral epicondyle in order to reduce the risk of nerve injury. After removal of intra-articular adhesions using this portal, the surgeon can create a conventional portal with better visualization using an intra-articular retractor. Capsular release is an essential step in treating stiff elbows. Radial nerve injury is possible when anterior capsular release is performed. Omid et al[17] studied the relationship of the radial nerve to the anterior capsule and concluded that arthroscopic capsular release laterally should be performed at the level of the joint line or above it. The most dangerous area for capsular resection is distally over the radial head/neck, where 50% of our specimens showed no brachialis protecting the nerve.

Third, intra-articular fractures caused by a previous trauma show the worse outcomes. As compared with extra-articular fractures caused by a previous trauma, intra-articular elbow fractures are technically difficult to treat, especially in low T-type distal humeral fractures. Technical difficulty may increase the chance of malunion and could pose an intrinsic risk by inducing mechanical block with malunited fragments. Intra-articular fracture can easily progress to post-traumatic arthritis as that occurring in knee arthritis.[21] In our results, 14 cases in group I were diagnosed with post-traumatic arthritis both arthroscopically and radiologically at the final follow-up, which may explain why group I showed the worse outcomes.

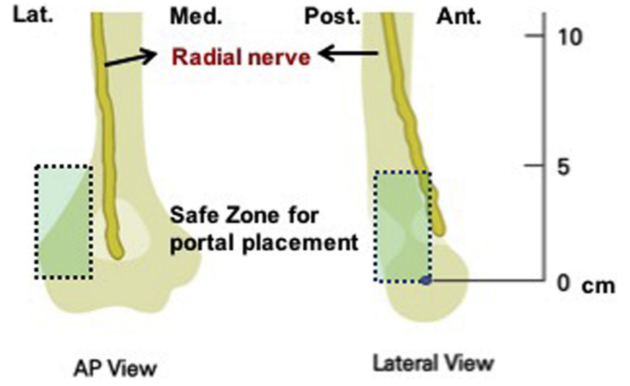

Figure 2 Anatomic considerations of the radial nerve in arthroscopic portal placement. *Lat.*, lateral; *Med.*, medial; *AP*, anteroposterior; *Post.*, posterior; *Ant.*, anterior.

Fourth, the symptom duration showed moderate or high correlation with the clinical outcomes (Table V). With the long symptom duration, intra-articular pathology and shortened muscles around the elbows tend to be aggravated because the remaining intra-articular pathology, including loose body and non- or malunited fragment, could accelerate the progress of post-traumatic arthritis. Although the surgeons manage intra-articular pathology properly, shortened muscles, such as the brachioradialis and triceps, could still act as an obstacle in achieving full ROM. To obtain more ROM, surgeons need to release these shortened muscles via detachment from the bone using a shaver or elevator.

Limitations

This study has several limitations. First, this study was performed using retrospective data that was not randomized. Second, a much higher percentage of men were included in the arthroscopic group than in the open group, which can be considered as a gender bias. Fourth, very specific indications for open/arthroscopic surgery might create a strong selection bias. Finally, this was a single-center study that involved unbalanced sampling between the 2 groups, which could have led to patient selection bias and other confounding factors.

Table V Correlation between symptom duration and clinical outcomes

	Symptom duration	VAS	ROM	MEPS
Symptom duration				
Pearson	1	0.475*	−0.469*	−0.778*
P value		.001	.001	<.001
N	44	44	44	44
VAS score				
Pearson	0.475*	1	−0.188	−0.361†
P value	.001		.22	.016
N	44	44	44	44
ROM				
Pearson	−0.469*	−0.188	1	0.612*
P value	.001	.22		<.001
N	44	44	44	44
MEPS				
Pearson	−0.778*	−0.361†	0.612*	1
P value	<.001	.016	<.001	
N	44	44	44	44

VAS, visual analog scale; *ROM*, range of motion; *MEPS*, Mayo Elbow Performance Score.
Pearson indicates Pearson correlation coefficient.
* $P < .05$.
† $P < .01$.

Conclusions

Arthroscopic osteocapsular arthroplasty is comparable to its corresponding open procedure with regard to our indications for post-traumatic elbow stiffness. The clinical outcomes in the intra-articular fracture group were worse than those in the extra-articular fracture group.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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