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Effects of arthroscopic pancapsular release for proximal humeral fractures treated with intramedullary nailing: a retrospective study

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Background: Proximal humeral fractures are one of the most common fractures in adults. Some patients treated operatively have restriction in range of motion (ROM) after surgery. This study aimed to evaluate arthroscopic pancapsular release in patients with severe stiffness after treatment with intramedullary nailing for proximal humeral fractures.

Methods: This study included 12 patients (7 women and 5 men) who underwent arthroscopic pancapsular release in the beach-chair position between May 2015 and February 2018. Intraoperative findings were recorded, and ordinary (with scapulothoracic motion) and true (without scapulothoracic motion) glenohumeral ROMs were measured with a goniometer. The American Shoulder and Elbow Surgeons shoulder score, Shoulder Rating Scale score of the University of California, Los Angeles scoring system, and Constant score were compared before and after the release. The Wilcoxon signed rank and Mann-Whitney *U* tests were used to analyze data.

Results: The average age of the patients was 65.1 years (standard deviation, 9.5 years), and the mean follow-up period after the release was 30.6 months (standard deviation, 11.7 months). All ROMs on the affected side after surgery were significantly greater than those before surgery in all directions. However, ROMs in forward flexion, lateral elevation, and external rotation with the arm at the side and at 90° of forward flexion on the affected side postoperatively were significantly lower than those on the unaffected side. All scores were significantly greater after surgery than before surgery.

Conclusion: Arthroscopic pancapsular release is effective for patients with proximal humeral fractures treated with intramedullary nailing.

Proximal humeral fractures are one of the most common fractures mainly because of an increase in the frequency of osteoporotic fractures among elderly individuals.[13] Most of these fractures are displaced or minimally displaced[18] and can be successfully treated conservatively.[10] However, there remain risks of humeral malunion, nonunion, stiffness, and post-traumatic arthrosis with conservative treatment.[4] In cases of displaced fractures, percutaneous pinning surgery, closed or open reduction and internal fixation, and arthroplasty can be treatment options, and there is no evidence of superiority among these treatment methods.[14] Among surgical procedures and with advancing technologies, locking plate fixation was the most common procedure for displaced proximal humeral fractures.[13]

Antegrade humeral intramedullary nail osteosynthesis has been developed to provide stability to a reduced fracture that allows for early motion to rehabilitate the shoulder and improve the patient's outcome.[4] The complications of treating proximal humeral fractures with antegrade nailing are similar to those of other common treatment modalities.[4] A prospective multicenter study of angular-stable intramedullary nail osteosynthesis and locking plate osteosynthesis showed equivalent complication rates.[6] When data

This study was approved by the Institutional Review Board of Tohoku University School of Medicine (approval no. 2015-1-483), and all procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the Declaration of Helsinki. All patients provided informed consent for the study and procedures.

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across all types of proximal humeral fractures were compiled, the complication rate for humeral intramedullary nail osteosynthesis was 11.9%.[15]

Shoulder stiffness is also a common complication, regardless of the treatment method used for proximal humeral fractures.[4] After locked plating of proximal humeral fractures, 39% of shoulders (18 of 46) experienced restricted passive range of motion (ROM), and a complete, arthroscopic, 270° capsular release induced significant recovery of ROM.[12] However, there has been no report about arthroscopic pancapsular release after proximal humeral fracture treatment with nailing.

The purpose of this study was to retrospectively evaluate arthroscopic pancapsular release in patients with proximal humeral fractures treated with intramedullary nailing. We hypothesized that stiffness after proximal humeral fracture treatment with nailing would be common and its release would be effective, similar to that in frozen shoulder.

Materials and methods

Patient selection

This study included 12 patients who underwent arthroscopic pancapsular release for severe shoulder stiffness with discomfort in activities of daily living between May 2015 and February 2018. The diagnosis of limitation in ROM comprised the following: (1) limitation in ROM for >3 months after primary surgery and (2) limitation in passive shoulder motion of ≤100° of forward flexion (FF), ≤20° of external rotation (ER) with the arm at the side, and ability to reach the fifth lumbar vertebra or less during the hand-behind-the-back (HBB) test, which was measured by asking the patient to place the thumb on the highest spinal vertebra he or she could possibly reach.[1,8,20] All criteria were required for the selection of patients. Patients with a history of fractures around the shoulder, dislocation of the shoulder, thyroid disorders, and/or diabetes mellitus were excluded.

Preoperative and postoperative treatment

For patients with severe pain, the shoulder was placed in a sling for a few days after primary surgery. After pain was relieved, physiotherapy—especially including scapulothoracic flexibility as well as glenohumeral motion—was initiated with the help of a physiotherapist who specialized in the shoulder, without a regional block, at an outpatient clinic. Stretching of the muscles around the spine, trunk, and hip joints was also performed.[7] For self-exercise, active FF with the patient in a lying position, in order to put the humeral head in a good position, with a support of the unaffected side with shake hands. On the basis of the patient's condition, a return to daily activities and strenuous labor was gradually permitted at up to approximately 2 months postoperatively.[7] If limited ROM remained after ≥4 months of physiotherapy and the patient had any discomfort, arthroscopic pancapsular release was recommended.[7,8]

ROM measurement

To evaluate the true glenohumeral ROM and exclude scapulothoracic motion, the scapula was first fixed by an examiner with 1 hand (without palpating the scapular motion), and the following motions were measured in the outpatient clinic[7]: passive ROM of FF (FF1), lateral elevation (LE1), ER with the arm at the side (ER1), ER at 90° of LE (ER2), internal rotation at 90° of LE (IR2), horizontal flexion (HF1), ER at 90° of FF (ER3), and internal rotation at 90° of FF (IR3). After evaluation of the true glenohumeral ROM, ordinary ROM including scapulothoracic motion was measured consecutively in FF (FF2), LE (LE2), and HF (HF2) and with the HBB test. ROMs between Neer 2-, 3-, and 4-part fractures were also compared.

Surgical technique and evaluation

All surgical procedures were performed by a single surgeon (K.K.). For the initial intramedullary nail osteosynthesis, all patients were placed in the beach-chair position. All humeral nails were inserted through an antegrade approach and included splitting of the rotator cuff. Fracture reduction was aided by C-arm image intensification and was performed closed in all cases. Proximal locking with 3 screws and distal locking with 2 screws were performed using the targeting device (Polarus 3 [Acumed, Hillsboro, OR, USA] in 1 patient; Multiloc [DePuy Synthes, Warsaw, IN, USA] in 3 patients; and T2 [Stryker, Kalamazoo, MI, USA] in 8 patients).

An arthroscopic pancapsular release, including total coracohumeral ligament (CHL) release, was performed in patients with severe ROM restriction.[7,8] The rotator interval, entire CHL including the subscapularis and supraspinatus portions, and middle glenohumeral ligament were dissected with forceps or a shaver until the conjoint tendon, coracoacromial ligament, and subscapularis tendon or muscle were in clear view. The superior capsule and anterior inferior glenohumeral ligament were dissected with a radiofrequency device. The posterior inferior glenohumeral ligament was released using a portal in the 7-o'clock position.[7,8] In patients with some limitation in ROM after pancapsular release, subacromial release was performed (Table I).

Statistical analysis

Continuous variables are presented as mean and standard deviation (SD). The Wilcoxon signed rank test was used to compare ROMs between the affected and unaffected sides both before surgery and after surgery; compare ROMs on the affected side before and after surgery; and compare the American Shoulder and Elbow Surgeons shoulder score, Shoulder Rating Scale score of the University of California, Los Angeles scoring system, and Constant score before and after surgery. Statistical analyses were performed using the statistical software package SPSS for Windows (version 23.0; IBM, Armonk, NY, USA).

Results

This study included 5 men (5 shoulders) and 7 women (7 shoulders) in whom shoulder stiffness was diagnosed after intramedullary nail osteosynthesis. The patients' mean age at the time of the operation was 65.1 years (range, 51-80 years; SD, 9.5 years), the mean follow-up time between the initial surgical procedure and the pancapsular release was 6 months (range, 3-14 months; SD, 3.13 months), and the mean follow-up time after the second surgical procedure was 30.6 months (range, 14-46 months; SD, 11.7 months). The right side was affected in 9 cases and the left, in 3. According to the Neer classification, 8 shoulders had 2-part fractures, 3 had 3-part fractures, and 1 had a 4-part fracture.[17] The AO classification was A2 for 8 shoulders, B1 for 1, and B3 for 3.[11] All patients had minimal or no displacement of the greater tuberosity. We observed no complications related to the initial open surgical procedure or systemic diseases other than stiffness. We also found no complications during and after arthroscopic pancapsular release, but the split site of the rotator cuff for intramedullary nailing was covered with fibrous tissue, with slight adhesion to the articular cartilage and subacromial bursa. There were no cases with

Table I
Intraoperative findings

	n (%)
RI thickening	11 (92)
RI synovitis	11 (92)
CHL adhesion	12 (100)
Abnormal LHB	2 (17)
Tear	1
Fibrillation	1
SLAP lesion	12 (100)
Type 1	9
Type 2	2
Type 3	1
Supracapsular adhesion	10 (83)
AIGHL thickening	12 (100)
PIGHL thickening	4 (33)
SAB adhesion	11 (75)

RI, rotator interval; *CHL*, coracohumeral ligament; *LHB*, long head of biceps tendon; *SLAP*, superior labrum anterior-posterior; *AIGHL*, anterior inferior glenohumeral ligament; *PIGHL*, posterior inferior glenohumeral ligament; *SAB*, subacromial bursa.

pathology of the long head of the biceps; however, there was 1 case of an articular perforated screw near the subscapularis tendon, and the screw was removed.

Characteristic findings of the glenohumeral space were a thickened rotator interval with synovitis and an anterior glenohumeral ligament; adhesion of the CHL and superior capsule, superior labrum anterior-posterior lesion, and normal long head of the biceps; and fibrillation or softening of the articular cartilage (Fig. 1, *A* and *B*; Table I). Adhesions were observed between the former skin incisions and the subacromial bursae, rotator cuff tendons, and articular cartilage, as well as superior capsule (Fig. 1, *C* and *D*). All ROMs on the affected side before the second surgical procedure were significantly lower than those on the unaffected side, but ROMs on the affected side after the second surgical procedure were significantly greater than those before the second surgical procedure (acquired ROM in FF1, 48°; FF2, 43°; LE1, 47°; LE2, 57°; ER1, 21°; ER2, 26°; IR2, 30°; HBB position, 4 vertebrae; HF1, 35°; HF2, 34°; ER3, 12°; and IR3, 33°). However, ROMs of FF1, FF2, LE1, LE2, ER2, and ER3 on the affected side after the operation were significantly lower than those on the unaffected side after the operation (Table II). All scores were significantly greater after surgery than before surgery (Table III). ROMs of 2-part fractures were significantly greater in FF1, FF2, LE1, LE2, ER1, and IR2, as well as the HBB position, before pancapsular release but in ER1 and IR2 after pancapsular release (Table IV). At the final follow-up, no patients had symptoms of impingement or refracture but 2 patients had discomfort.

Discussion

The most important finding of this study was that arthroscopic pancapsular release is an effective procedure for stiffness after proximal humeral fracture treatment with intramedullary nail osteosynthesis. Recently, arthroscopic capsular release has been applied to patients with a combination of postoperative and post-traumatic shoulder stiffness.[5,12,23] During the procedure, the subacromial space was débrided. In this series, subacromial bursectomy was performed in 75% of patients to regain ROM, but the rest of them did not need subacromial bursectomy because they gained sufficient ROM. The implants had passed through the supraspinatus tendon; thus, concomitant thickening or adherence of the bursae could occur around the skin incision. Furthermore,

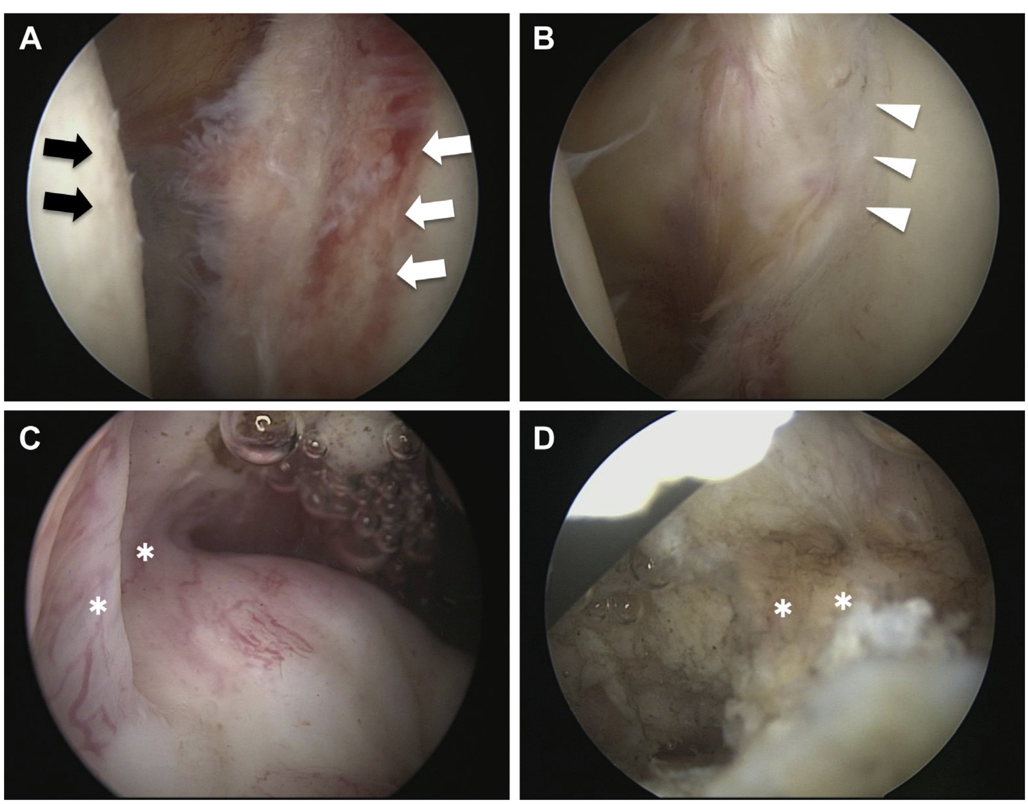

Figure 1 Arthroscopic findings during pancapsular release. (**A**) Chondral lesions in humeral head and glenoid. The *black arrows* indicate articular damage to the humeral head, and the *white arrows* indicate articular damage to the glenoid. (**B**) Labral tear (*arrowheads*) in anterior glenoid rim. (**C**) Adhesions (*) between humeral head articular cartilage and superior joint capsule. (**D**) Adhesions (*) between acromion and rotator cuff (subacromial space).

Table II
Comparison of ROM between unaffected and affected sides

ROM	Unaffected	Affected		P value		
		Before surgery	After surgery	Comparison between unaffected and affected sides before surgery	Comparison of affected side before and after surgery	Comparison between unaffected and affected sides after surgery
FF1, °	138 (14.4)	66 (17.9)	114 (18)	<.001	<.001	.0078
FF2, °	160 (14.9)	90 (16.7)	133 (15.7)	<.001	<.001	<.001
LE1, °	142 (16.4)	60 (17.1)	107 (18.4)	<.001	<.001	<.001
LE2, °	178 (8.7)	88 (18.4)	145 (23.9)	<.001	<.001	<.001
ER1, °	52 (13.1)	20 (19.8)	41 (15.5)	<.001	<.001	.073
ER2, °	86 (11)	49 (15.6)	75 (11.7)	<.001	<.001	.031
IR2, °	19 (4.7)	−13 (14.4)	17 (9.6)	<.001	<.001	.52
HBB	T8 (T6-T8)	L5 (L2-B)	T9 (T8-T12)	<.001	<.001	.068
HF1, °	15 (11)	−17 (9.2)	18 (11.4)	<.001	<.001	.679
HF2, °	47 (16.6)	6 (8.8)	40 (10.1)	<.001	<.001	.194
ER3, °	87 (9.2)	61 (10.9)	73 (12.3)	<.001	.0086	.006
IR3, °	13 (11.8)	−23 (12.9)	10 (11.1)	<.001	<.001	.44

ROM, range of motion; *FF1*, forward flexion with scapular fixation; *FF2*, forward flexion without scapular fixation; *LE1*, lateral elevation with scapular fixation; *LE2*, lateral elevation without scapular fixation; *ER1*, external rotation with arm at side; *ER2*, external rotation at 90° of abduction; *IR2*, internal rotation at 90° of lateral elevation; *HF1*, horizontal flexion with scapular fixation; *HF2*, horizontal flexion without scapular fixation; *ER3*, external rotation at 90° of forward flexion; *IR3*, internal rotation at 90° of forward flexion; *HBB*, the hand-behind the-back; *B*, buttock; *T*, thoracic spine; *L*, lumbar spine.
Data are presented as mean (standard deviation).

intra-articular adhesions between the humeral articular cartilage and superior capsule were observed, but they were very thin compared with the subacromial space. Intra-articular hemorrhage after the initial surgical procedure might induce these adhesions.[19] Hence, subacromial adhesion should be considered as a cause of ROM restriction.

Arthroscopic capsular release has an advantage for evaluating intra-articular pathology. Intraoperative findings after locked plating of proximal humeral fractures were chondral damage associated with articular perforation, a lesion of the long head of the biceps tendon, and partial articular avulsion of the supraspinatus tendon.[12] In this series, fewer lesions of the long head of the biceps tendon and rotator cuff were found. However, chondral damage and labral tears at around the 3- to 12-o'clock position in a right shoulder were observed. Only 1 patient with a perforated screw was observed, and treatment was performed simultaneously; the other cases with chondral damage were not related to screw perforation. Other mechanisms such as subchondral bone damage from the initial injury, screw perforation, joint hemorrhage, and abnormal stress owing to stiffness during motion could affect the pathology. For patients with an anterior labral tear, surgical repair was not needed in this series. After release of the anterior joint capsule between the subscapularis tendon and labrum, the labrum was returned to its proper place without any instability and tension during glenohumeral motion. Adhesion between the joint capsule and labrum could induce labral tears during glenohumeral motion.[21]

Conventional ROM of the shoulder comprises a combined motion of the glenohumeral joint and scapulothoracic joint. However, measuring the true ROM of the glenohumeral joint is necessary to evaluate the capsular effects on ROM.[7] Evaluation of the true ROM of the glenohumeral joint with scapular fixation is a reliable method during surgery, as well as in the outpatient clinic.[7] ROMs after capsular release were inferior to those on the unaffected side. Furthermore, 2-part fractures had superior ROMs after pancapsular release compared with 3- and 4-part fractures. Pancapsular release in patients with frozen shoulder showed excellent results with almost full ROM and function.[2,8,9,16] When considering release of the whole joint capsule including the CHL and subacromial bursae, one should consider other effects of scapulothoracic motion relating to muscle damage during injury or adhesion around the muscles.[22] Further studies are needed to explain the inferiority of this treatment method.

Table III
Comparison of shoulder scores on affected side before and after pancapsular release

Score	Before surgery	After surgery	P value
ASES shoulder score	44.8 (8.5)	86.6 (7.8)	<.001
UCLA score	16.4 (1.9)	30.3 (3.5)	<.001
Constant score	51 (7.1)	90.6 (4.3)	<.001

ASES, American Shoulder and Elbow Surgeons; *UCLA*, Shoulder Rating Scale of University of California, Los Angeles scoring system.
Data are presented as mean (standard deviation).

This study has several limitations. First, surgery was performed and ROMs were evaluated by a single surgeon. However, additional research should perform reliability testing, such as inter-rater reliability testing. Second, ROM was not evaluated during pancapsular release. In patients with frozen shoulder, adhesion areas were complex, and each capsular effect on ROM was difficult to evaluate during surgery. Third, an a priori sample size calculation was not conducted, and the number of patients was small. We conducted post hoc power analyses for each ROM and score. The power estimates for the comparisons that did not show statistical significance, such as ER1, IR2, HF1, HF2, and IR3, ranged from 0.12 to 0.61 between the unaffected and affected sides after surgery. These data were lower than the conventionally accepted power level of 0.80.[3] Increasing the sample size and performing an a priori sample size calculation could improve our power to detect differences that currently do not reach statistical significance.

Conclusion

Arthroscopic pancapsular release in patients with shoulder stiffness after proximal humeral fracture treatment with nailing was an effective treatment method for recovering ROM and function. Shoulder stiffness after proximal humeral fracture treatment must be the focus, and further studies related to glenohumeral motion should be conducted.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any

Table IV
Comparison of ROM between 2-part and 3- or 4-part fractures

ROM	Before surgery			After surgery		
	2-part fracture	3- or 4-part fracture	*P* value	2-part fracture	3- or 4-part fracture	*P* value
FF1, °	74 (7.9)	50 (23.1)	.0217	121 (16.1)	100 (14.1)	.0557
FF2, °	98 (10.7)	75 (17.3)	.0182	137 (16.9)	125 (10)	.208
LE1, °	68 (11.6)	45 (17.3)	.0223	113 (19.8)	95 (5.8)	.11
LE2, °	94 (16)	75 (17.3)	.0841	154 (24.5)	128 (9.6)	.0699
ER1, °	29 (9.4)	0 (21.6)	.0264	48 (14.6)	28 (5)	.0071
ER2, °	50 (18.5)	48 (9.6)	.808	79 (9.9)	68 (12.6)	.119
IR2, °	−8 (13.9)	−25 (5.8)	.0391	23 (4.6)	6 (7.5)	<.001
HBB	L4 (L2-L5)	B (B-B)	.036	T10 (T9-T11)	T11 (T8-L2)	.549
HF1, °	74 (9.8)	70 (8.2)	.462	109 (11.3)	105 (12.9)	.614
HF2, °	98 (10)	92.5 (5)	.32	131 (10.8)	128 (9.6)	.937
ER3, °	64 (11.9)	56 (7.5)	.281	76 (12.2)	65 (10)	.143
IR3, °	−18 (11.6)	−33 (9.6)	.0513	14 (8.8)	2.5 (12.6)	.098

ROM, range of motion; *FF1*, forward flexion with scapular fixation; *FF2*, forward flexion without scapular fixation; *LE1*, lateral elevation with scapular fixation; *LE2*, lateral elevation without scapular fixation; *ER1*, external rotation with arm at side with scapular fixation; *ER2*, external rotation at 90° of abduction with scapular fixation; *IR2*, internal rotation at 90° of lateral elevation with scapular fixation; *HF1*, horizontal flexion with scapular fixation; *HF2*, horizontal flexion without scapular fixation; *ER3*, external rotation at 90° of forward flexion with scapular fixation; *IR3*, internal rotation at 90° of forward flexion with scapular fixation; *HBB*, the hand-behind the-back; *B*, buttock; *T*, thoracic spine; *L*, lumbar spine.
Data are presented as mean (standard deviation).

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