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Clinical and Radiologic Outcomes of Open Reduction and Internal Fixation without Capsular Incision for Inferior Glenoid Fossa Fractures

Ji-Kang Park, MD, Ho-Seung Jeong, MD*

Department of Orthopaedic Surgery, Chungbuk National University College of Medicine, Cheongju,
**Department of Orthopaedic Surgery, Chungbuk National University Hospital, Cheongju, Korea*

Background: Scapular surgery is usually undertaken via the posterior approach described by Judet. This approach allows access to the entire posterior scapular body; however, it results in severe soft-tissue injury and requires an incision in the deltoid muscle. To date, no clinical study has been reported on open reduction and internal fixation without capsular incision for displaced inferior glenoid fractures (Ideberg type II). The purpose of this study was to introduce an easy and less invasive approach to the inferior glenoid fossa and evaluate its clinical outcomes.

Methods: Ten patients with displaced inferior glenoid fractures underwent open reduction and internal fixation without capsular incision between January 2017 and July 2018. Postoperative computed tomography was performed to evaluate the reduction state within a week of the surgery. Clinical and radiological data from 7 patients who were followed up for more than 2 years were analyzed.

Results: The mean age of the patients was 61.7 years (range, 35–87 years). The mean follow-up period was 28.6 months (range, 24–42 months). The mean preoperative fracture gap and step-off values were 12.3 ± 4.4 mm and 6.8 ± 4.0 mm, respectively. Surgical stabilization was conducted 6.4 days (range, 4–13 days) after trauma. Mean postoperative-preoperative fracture gap and step-off values were 0.6 ± 0.6 mm and 0.6 ± 0.8 mm, respectively. At 24 months after surgery, the mean Constant score was 89.1 ± 10.6 points (range, 69–100) and the mean pain visual analog scale score was 1.4 ± 1.7 (range, 0–5). Bony union was observed in all patients. The mean time to bony union was 11 ± 1.7 weeks. The mean active range values for forward elevation, external rotation, and abduction were 162.9° ± 11.1° (range, 150°–180°), 55.7° ± 15.1° (range, 30°–70°), and 158.6° ± 10.7° (range, 150°–180°), respectively.

Conclusions: The presented posterior open reduction and internal fixation without capsular incision or extensive soft-tissue dissection may be an easy and less invasive surgical approach for inferior glenoid fossa fractures (Ideberg type II).

Keywords: *Scapula, Glenoid cavity, Fracture, Operative procedure*

Scapular fractures account for 1% of all fractures, and the glenoid is involved in up to 20% of all scapular fractures.[1-3]

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Correspondence to: Ho-Seung Jeong, MD
Department of Orthopaedic Surgery, Chungbuk National University Hospital,
776 1(il)sunhwan-ro, Heungdeok-gu, Cheongju 28644, Korea
Tel: +82-43-269-6077, Fax: +82-43-269-6359
E-mail: turbox2@hanmail.net

Scapular fractures usually occur as a result of high energy trauma. The fracture mechanism is not always clear, but fossa fractures are mostly observed after a direct impact of the humeral head onto the glenoid fossa. The degree of displacement and location of fractures are important in decision-making regarding operative or nonoperative treatment. Classification systems have been typically designed based on the site and severity of the fracture pattern. If untreated, displaced glenoid fractures may lead to malunion, instability, and glenohumeral osteoarthritis, all of which can cause shoulder motion limitations and per-

sistent pain. Over time, the treatment of scapula fractures has changed from preferably conservative to operative. Lantry et al.[4] and Zlowodzki et al.[5] reported that operative treatment was used in 80% of all glenoid fractures, with good to excellent results in 82% of the operated cases.

Scapular surgery is usually undertaken via the posterior approach described by Judet.[6] This approach allows access to the entire posterior scapula body, but causes severe soft tissue injury and requires incision of the deltoid muscle. Fandridis et al.[7] reported the clinical outcomes of a deltoid preserving approach for displaced extra-articular scapular fractures. In a cadaveric study, Jerosch et al.[8] reported that the posterior subdeltoid approach can provide access to the glenoid neck between the infraspinatus and teres minor, without deltoid injury. However, it is difficult to open the joint without damaging the tendons or muscles of the infraspinatus and teres minor.

Thus, the purpose of this study was to propose a straightforward and relatively less invasive approach to the inferior glenoid fossa fracture and to evaluate the clinical and radiological outcomes following open reduction and internal fixation (ORIF) without capsular incision. We hypothesized that ORIF without capsular incision may be a suitable treatment option for inferior glenoid fossa fractures even though the articular surface cannot be observed.

METHODS

Study Design

This retrospective study was approved by the Institutional Review Board of Chungbuk National University Hospital (No. CBNUH 2020-11-009-001), and the need for patient informed consent was waived due to its retrospective design. However, written informed consent for publication of the photographs was obtained from the participant of Fig. 1. All patients who had a surgically treated glenoid fossa fracture from January 2017 to July 2018 were identified by querying a hospital surgical database. Patients who underwent surgical treatment for inferior glenoid fractures (Ideberg type II) and who were 18 years old or older were included. The operative indication was displacement of articular fragments (gap or step-off of more than 3 mm).[3,9]

Surgical Technique

Patients were placed in the prone position with a pad under the chest, with a thicker pad applied on the fracture side. We adjusted the height of the pad or tilted the table so that the scapular plane was parallel to the floor and so that the glenoid could be easily accessible to C-arm fluoroscopy from the contralateral side or cephalic side (Fig. 1). The arm was abducted and draped free. A straight skin incision of 8–10 cm was made over the lateral border of the scapula, with 90° abduction of the arm (Fig. 2), as such an incision can facilitate the expansion of the incision to the scapular body and inferior angle.

The deltoid fascia was dissected, and the inferior border of the deltoid muscle was visualized (Fig. 2). The deltoid muscle was retracted cephalad, and the underlying infraspinatus and teres minor muscles were identified. Dissection was performed between the infraspinatus and teres minor, and the infraspinatus muscle was elevated proximally, while the teres minor muscle was retracted distally to expose the infraspinous fossa and posterior joint capsule. A long head of triceps is attached to the lower part of the joint capsule, and when partially detached for screws insertion, the remaining triceps long head can be gently retracted laterally to protect the axillary nerve. The

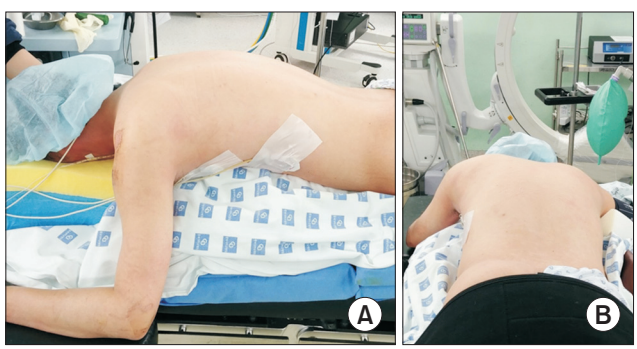

Fig. 1. (A) The patient is in the prone position with a pad under the chest and with a thicker pad applied on the fracture side. (B) The thickness of the pad or tilt of the table is adjusted such that the scapular plane is parallel to the floor.

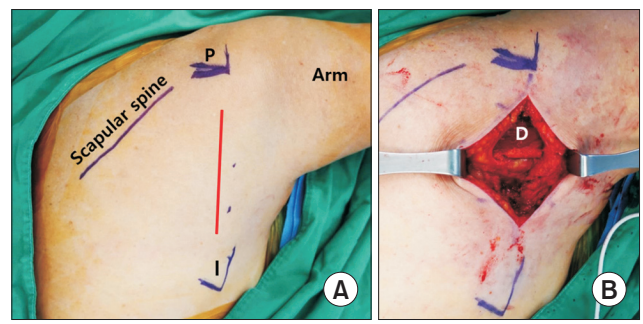

Fig. 2. (A) An 8–10 cm straight skin incision (red line) is made over the lateral border of the scapula, with the arm in 90° abduction. (B) Dissection of deltoid fascia is performed and the inferior border of the deltoid muscle is visualized. P: posterior angle of acromion, I: inferior angle of scapula, D: deltoid.

interval between the infraspinatus and teres minor may be difficult to find. It is more easily found medially rather than laterally where the muscle fibers are conjoined. When the incision was extended for wider access to the inferior scapular body, the circumflex scapular artery could be identified on the lateral scapular border and was tied to prevent bleeding (Fig. 3).

The fracture was reduced by aligning the posterior fracture line under fluoroscopy. The fragments were held temporarily in the reduced position with a 1.6-mm Kirschner wire (K-wire). One or two 4.0-mm partial-thread cannulated screws were inserted through the guide pin or temporary K-wire after reaming (Fig. 4).

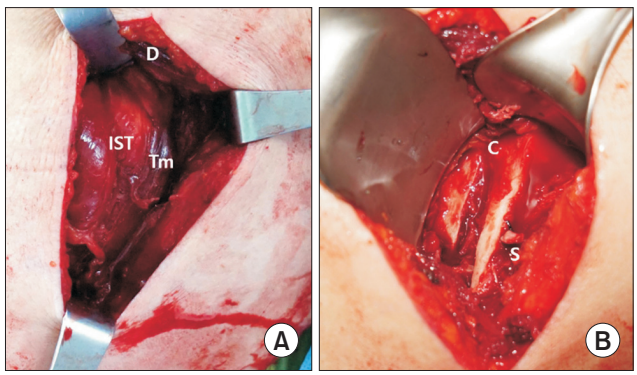

Fig. 3. (A) The deltoid muscle is retracted cephalad, and the underlying infraspinatus and teres minor muscles are identified. (B) The infraspinatus muscles are elevated proximally, and the teres minor muscle is retracted distally to expose the infraspinous fossa and posterior joint capsule. When the incision is extended for wider access to the inferior scapular body, the circumflex scapular artery is identified on the lateral border of the scapula. This artery is tied to prevent bleeding. D: deltoid, IST: infraspinatus, Tm: teres minor, C: posterior capsule, S: tied circumflex scapular artery.

Postoperative Rehabilitation

All patients followed the same rehabilitation regimen. The shoulders were immobilized for 6 weeks with an abduction brace. Range of motion (ROM) exercises for the elbow, wrist, and fingers were started immediately after surgery. Passive ROM exercises began at 1 week after surgery within the patient's tolerance of pain. Active-assisted ROM exercises were allowed after the patients were released from the brace. Muscle strengthening regimens were started at 12 weeks.

Postoperative Evaluation

Postoperative and follow-up radiographs included scapular anteroposterior, lateral, and axillary lateral views of the shoulder at 1, 2, 6, and 12 weeks, 6 and 12 months, and 2 years after surgery. In all patients, the success of reduction and restoration of the articular surface was judged from postoperative three-dimensional computed tomography (CT) images obtained within a week after surgery. All patients were followed up until they had pain-free shoulder motion, no tenderness at the incision site, and fracture union visible on radiographs.

Clinical assessment consisted of shoulder active ROM, pain visual analog scale (VAS) score, and functional score (Constant score). Internal rotation capacity was recorded as the highest vertebral level a patient could reach with the hand of the affected side on his or her back. These outcome measures were evaluated postoperatively at 24 months after surgery.

RESULTS

Between January 2017 and July 2018, 45 patients presented with a scapular fracture at our trauma center or the emergency room. Thirteen patients had inferior glenoid fractures (Ideberg type II). Ten of these patients

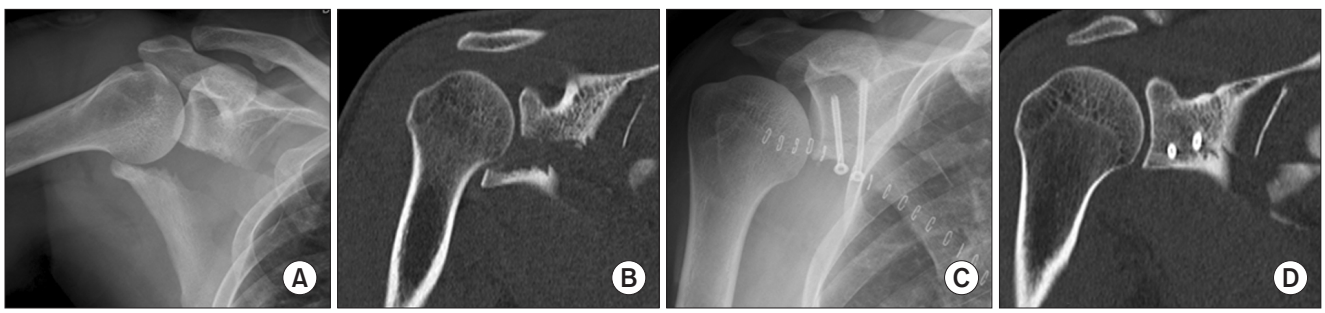

Fig. 4. Preoperative simple radiography (A) and three-dimensional computed tomography (CT) (B) scans show a displaced inferior glenoid fossa fracture. Two 4.0-mm partial thread cannulated screws are inserted (C), and postoperative CT scan shows excellent congruency of the articular surface of glenoid fossa (D).

underwent ORIF without capsular incision by the interteres approach. Postoperative CT scans were performed to evaluate the reduction state. Seven patients were followed up for more than 2 years; these included 2 female and 5 male patients. The mean age of the patients was 61.7 years (range, 35–87 years). The mean follow-up period was 28.6 months (range, 24–42 months) (Table 1).

Table 1. Patient Demographic Characteristics

Patient number	Age (yr)	Sex	Injured side	Cause of injury	Associated injury
1	73	Female	Right	Falling down	-
2	59	Male	Left	Bicycle accident	Rib fractures
3	52	Male	Left	Falling from a height	Cerebral hemorrhage, clavicle fracture, rib fractures
4	87	Female	Right	Falling down	Posterior dislocation of shoulder
5	35	Male	Right	Motorcycle accident	Cerebral contusion, cervical spine fracture
6	73	Male	Right	Pedestrian traffic accident	Cerebral contusion, rib fractures, femur shaft fracture
7	53	Male	Right	Pedestrian traffic accident	Pelvic ring injury, lumbar spine fracture, rib fractures

Six of the seven patients had additional associated injuries, mostly of the thorax and brain. Five patients had severe traumatic injury (injury severity score of > 15 points).[10] All patients had two-part articular fractures. The mean preoperative fracture gap and step-off values were 12.3 ± 4.4 mm (range, 6.3–19.6 mm) and 6.8 ± 4.0 mm (range, 2.8–13.6 mm), respectively. Associated ipsilateral clavicle fractures occurred in 3 patients, and acromial fractures occurred in 2 patients. Four patients had multiple rib fractures, and two patients had spine fractures. One patient had an axillary nerve injury and recovered at 4 months postoperatively. The other injuries are listed in Table 1, and the only complication was posttraumatic arthritis of the hip (patient number 7). Surgical stabilization was conducted on average at 6.4 days (range, 4–13 days) after trauma. The mean postoperative-preoperative fracture gap and step-off values were 0.6 ± 0.6 mm (range, 0–1.6 mm) and 0.6 ± 0.8 mm (range, 0–2.1 mm), respectively (Table 2).

Bony union was observed in all patients at a mean of 11 ± 1.7 weeks (range, 8–12 weeks). There were 2 complications: 1 patient had irritation due to the long length of the screw, and only this patient underwent metal removal. One patient had adhesive capsulitis of the shoulder joint and was cured by passive motion rehabilitation lasting 2 months. At 24 months after surgery, the mean Constant score was 89.1 ± 10.6 points (range, 69–100 points) and the mean pain VAS score was 1.4 ± 1.7 points (range, 0–5 points). The mean active range values of forward elevation, external rotation, and abduction were 162.9° ± 11.1°

Table 2. Radiological Results

Patient number	Fracture type (Ideberg)	Time to bony union (wk)	Step off (mm)			Displacement (mm)		
			Preop	Postop	*p*-value	Preop	Postop	*p*-value
1	II	12	3.46	0.00		10.56	0.32	
2	II	10	7.03	0.64		8.66	0.51	
3	II	12	5.01	2.07		13.17	0.65	
4	II	12	10.60	0.51		12.08	1.62	
5	II	8	13.63	0.00		19.59	0.00	
6	II	12	5.07	0.00		6.33	0.20	
7	II	12	2.80	0.91		15.66	1.01	
Mean ± SD		11.1 ± 1.6	6.8 ± 4.0	0.6 ± 0.8	0.008*	12.3 ± 4.4	0.6 ± 0.6	< 0.001*

Preop: preoperative, Postop: postoperative, SD: standard deviation.
*Paired *t*-test.

Table 3. Clinical Results at 2 Years after Surgery

Patient number	Pain VAS score	Constant score	ROM (2 years after surgery)		
			Forward elevation (°)	External rotation (°)	Abduction (°)
1	2	85	150	50	150
2	1	87	160	30	150
3	1	92	170	70	160
4	4	69	150	50	150
5	0	98	180	70	180
6	0	95	160	70	160
7	1	91	170	50	160
Mean ± SD	1.4 ± 1.7	88.1 ± 9.5	162.9 ± 11.1	55.7 ± 15.1	158.6 ± 10.7

VAS: visual analog scale, ROM: range of motion, SD: standard deviation.

(range, 150°–180°), 55.7° ± 15.1° (range, 30°–70°), and 158.6° ± 10.7° (range, 150°–180°), respectively (Table 3).

DISCUSSION

In this study, the approach used for surgical repair of glenoid fractures is compatible with fluoroscopy use and allows reduction and fixation without capsular incision. If capsular incision is not necessary, dissection between tendons (infraspinatus, teres minor) and posterior joint capsule is not required, making the operation easier and helping prevent iatrogenic damage to the rotator cuff tendon and joint cartilage. Clinical and radiological follow-up of our patients showed good results.

Conservative treatment is generally recommended for scapular fractures; however, surgical treatment is recommended for displaced intra-articular glenoid fractures to reduce the risk of posttraumatic osteoarthritis or shoulder instability.[3] The indications for surgical management include an articular gap or step-off values between 3 and 10 mm, 20% and 30% involvement of the articular surface, and instability of the glenohumeral joint.[2,3,11-13] Our indication for treatment was an articular fracture gap or step-off value of ≥ 3 mm.

Soft-tissue management and fracture exposure are important in surgery; however, for the glenoid fracture, this is difficult because glenoid fractures are rare, and most surgeons are relatively inexperienced. In previous studies, most open reduction methods used the Judet's approach with good results.[3,12,14-17] However, this approach is extensive and causes marked damage to the soft tissue and deltoid muscle. Moreover, in the lateral decubitus position, because fluoroscopy cannot be easily implemented, this approach is challenging for inexperienced surgeons. Therefore, conservative treatment rather than surgical treatment is preferred, regardless of the indication for surgery; moreover, if the gap or step-off is large, the outcome tends to be poor.

It has been reported that soft-tissue damage can be minimized by performing arthroscopic treatment.[18-23] This treatment is mainly performed for Ideberg type III or Ia factures and is difficult to apply for Ideberg type II or Ib fractures. For Ideberg type II cases, ideal fixation (perpendicular to the fracture line) requires screw insertion at the 6 o'clock position, but arthroscopic fixation is difficult because of the risk of axillary nerve injury. A previously published technical note on arthroscopic fixation in Ideberg type V cases reported insertion of the screw percutaneously into the posteroinferior portal, but the direction of screw insertion had limitations, as illustrated in the report.[19]

In this study, a straightforward method was introduced, and accurate reduction was achieved for posterior open reduction without capsular incision or extensive soft-tissue dissection, which is required with the Judet approach. To our knowledge, no previous study has evaluated the outcomes after ORIF of glenoid fossa fractures without capsular incision. As it was not confirmed by opening the capsule, reduction of the articular surface may be a concern; however, a postoperative CT scan confirmed that good reduction was achieved by adjusting the shape of the posterior cortical bone and fixing the screw perpendicular to the fracture surface. Previous studies used only simple radiography for postoperative assessment. However, simple radiography alone does not provide an accurate assessment of the gap and step-off of the glenoid fossa. Depending on the angle of the fracture line, one or two screws were inserted from the 6 to 8 o'clock positions, and sufficient fixation force was obtained. A 4.0-mm partial-thread cannulated compression screw was used to fix it through the far cortex because cancellous bone fixation was not sufficient to obtain strong fixation of the glenoid fracture. Cortical screws can be fixed in the same way, but it was difficult to check the direction of the screw before insertion. Moreover, accompanying scapular body fractures were noted in 3 patients. In these patients, only glenoid reduction and fixation, without body fixation, were performed; nevertheless, satisfactory results with an average Constant score of 81.2 points were obtained. In two patients, the anterior cortical bone of the scapula was penetrated more than 5 mm, and the tip of the screw was

placed inside the subscapular muscle. One of two patients continued to complain of discomfort in the anterior shoulder joint, and the symptoms improved after the removal of the screws. There was no postoperative neurological symptom, and 1 case of preoperative axillary nerve palsy had recovered by 4 months after injury.

Our study has several limitations. First, the number of cases enrolled in our study was small due to the rarity of this fracture. Second, the follow-up time was too short to allow for any analysis of the risk factors for posttraumatic arthritis; however, it was sufficient to evaluate the maintenance rates of fixation, bony union, and clinical outcomes. Another concern was the radiation exposure from postoperative CT scanning. Since the scan proved that the reduction and fixation without capsular incision is excellent, in future surgeries, we will employ CT scanning only when the reduction is not satisfactory.

In conclusion, this novel posterior ORIF without capsular incision or extensive soft-tissue dissection can be a straightforward surgical approach for inferior glenoid fossa fractures (Ideberg type II).

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Ji-Kang Park https://orcid.org/0000-0002-8653-549X
Ho-Seung Jeong https://orcid.org/0000-0001-7297-5534

REFERENCES

1. Konigshausen M, Coulibaly MO, Nicolas V, Schildhauer TA, Seybold D. Results of non-operative treatment of fractures of the glenoid fossa. Bone Joint J. 2016;98(8):1074-9.
2. Goss TP. Fractures of the glenoid cavity. J Bone Joint Surg Am. 1992;74(2):299-305.
3. Adam FF. Surgical treatment of displaced fractures of the glenoid cavity. Int Orthop. 2002;26(3):150-3.
4. Lantry JM, Roberts CS, Giannoudis PV. Operative treatment of scapular fractures: a systematic review. Injury. 2008;39(3):271-83.
5. Zlowodzki M, Bhandari M, Zelle BA, Kregor PJ, Cole PA. Treatment of scapula fractures: systematic review of 520 fractures in 22 case series. J Orthop Trauma. 2006;20(3):230-3.
6. Judet R. Surgical treatment of scapular fractures. Acta Orthop Belg. 1964;30:673-8.
7. Fandridis E, Anastasopoulos PP, Alexiadis G, Nomikarios D, Spyridonos S, Hertel R. Posterior subdeltoid and external rotators preserving approach for reduction and fixation of displaced extra-articular fractures of the scapula. Eur J Orthop Surg Traumatol. 2018;28(4):585-91.
8. Jerosch J, Greig M, Peuker ET, Filler TJ. The posterior subdeltoid approach: a modified access to the posterior glenohumeral joint. J Shoulder Elbow Surg. 2001;10(3):265-8.
9. Kavanagh BF, Bradway JK, Cofield RH. Open reduction and internal fixation of displaced intra-articular fractures of the glenoid fossa. J Bone Joint Surg Am. 1993;75(4):479-84.
10. Copes WS, Champion HR, Sacco WJ, Lawnick MM, Keast SL, Bain LW. The injury severity score revisited. J Trauma. 1988;28(1):69-77.
11. Papagelopoulos PJ, Koundis GL, Kateros KT, Babis GC, Nikolopoulos KE, Fragiadakis EG. Fractures of the glenoid cavity: assessment and management. Orthopedics. 1999;22(10):956-61.
12. Mayo KA, Benirschke SK, Mast JW. Displaced fractures of the glenoid fossa: results of open reduction and internal fixation. Clin Orthop Relat Res. 1998;(347):122-30.
13. Wilber MC, Evans EB. Fractures of the scapula: an analysis of forty cases and a review of the literature. J Bone Joint Surg Am. 1977;59(3):358-62.
14. Schroder LK, Gauger EM, Gilbertson JA, Cole PA. Functional outcomes after operative management of extra-articular glenoid neck and scapular body fractures. J Bone Joint Surg Am. 2016;98(19):1623-30.
15. Leung KS, Lam TP, Poon KM. Operative treatment of displaced intra-articular glenoid fractures. Injury. 1993;24(5):324-8.
16. Jones CB, Cornelius JP, Sietsema DL, Ringler JR, Endres TJ. Modified Judet approach and minifragment fixation of scapular body and glenoid neck fractures. J Orthop Trauma. 2009;23(8):558-64.
17. Schandelmaier P, Blauth M, Schneider C, Krettek C. Fractures of the glenoid treated by operation: a 5- to 23-year follow-up of 22 cases. J Bone Joint Surg Br. 2002;84(2):173-7.
18. Goss DA, Persinger F, Triplet JJ, Taylor BC, Long N. Arthroscopically assisted reduction and internal fixation of a

displaced posterior glenoid fracture: a case report. JBJS Case Connect. 2017;7(4):e84.

19. Tuman JM, Bishop JA, Abrams GD. Arthroscopic reduction and internal fixation of an inferior glenoid fracture with scapular extension (Ideberg V). Arthrosc Tech. 2015;4(6):e869-72.

20. Voleti PB, Camp CL, Sinatro AL, Dines JS. Arthroscopic fixation of glenoid rim fractures after reduction by labral repair. Arthrosc Tech. 2016;5(2):e379-83.

21. Yang HB, Wang D, He XJ. Arthroscopic-assisted reduction and percutaneous cannulated screw fixation for Ideberg type III glenoid fractures: a minimum 2-year follow-up of 18 cases. Am J Sports Med. 2011;39(9):1923-8.

22. Papadonikolakis A. Arthroscopic reduction and fixation of transverse intra-articular glenoid fractures with scapular extension. Arthrosc Tech. 2017;6(3):e879-85.

23. Tucker A, Donnelly K, Murphy L, Ferguson G, Sloan S, Charlwood P. Percutaneous arthroscopic-assisted glenoid fixation: a novel surgical technique. J Orthop Case Rep. 2018;8(4):3-6.