석 사 학 위 논 문

Pure Varus Posteromedial Rotatory Instability of the Elbow: Radiographic Findings, Treatment, and Outcomes

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2023년 8월

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이 논문을 석사학위 논문으로 제출함

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김 지 훈

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1. Introduction

Varus posteromedial rotatory instability (VPMRI) is a relatively rare, but subtle elbow injury that involves anteromedial coronoid facet (AMCF) fracture and ligamentous injuries by an injury mechanism associated with varus, axial force, and forearm pronation (4,3,1,2). VPMRI was first described in 2003 by O'Driscoll et al. who proposed a novel classification for coronoid fractures based on fracture location and size, which can predict associated injuries and injury mechanism (6,8,7,5). O'Driscoll type 2 coronoid fracture involves the anteromedial facet and classified 3 subtypes: anteromedial subtype I involves the rim; subtype II, the rim and tip; and subtype III the rim and sublime tubercle in which anterior bundle of the medial collateral ligament (MCL) is attached. They highlighted the importance of the AMCF region that resists varus forces across the ulnohumeral joint along with the lateral collateral ligament (LCL) (6). Approximately 60% of the AMCF is not supported by the proximal ulnar metaphysis and diaphysis, thus it is vulnerable to the type of fracture that leads to VPMRI (9,8,11,10). Opening of the lateral side of the ulnohumeral joint may occur even in AMCF fractures with a small fragment (7). As a result, loading is increased on the medial side of the ulnohumeral joint under gravitational varus stress, which can lead to early-onset medial ulnohumeral arthritis resulting from joint incongruity (7).

Doornberg and Ring (12) reported 18 cases of AMCF fracture with a mean follow-up period of 26 months. Twelve of 18 cases had good or excellent clinical outcomes by sufficient fixation of AMCF fracture, but the remaining 6 cases with inadequate stability of AMCF fracture had unsatisfactory clinical outcomes with residual instability and posttraumatic arthritis (12). Due to the high incidence of residual instability and early-onset posttraumatic arthritis with improper treatment, operative treatment has been recommended in patients with VPMRI (12,11,1). Based on findings from clinical and biomechanical studies, the treatment should include either AMCF fracture fixation or LCL repair, or a combination of these techniques (21,14,15,18,17,16,19,13,20). However, it is not clear whether operative treatment in patients with VPMRI is always beneficial because most clinical studies included a small case series with no control group. Although there is a lack of available evidence, satisfactory outcomes have been reported with nonoperative treatment in some cases of VPMRI (25,24,22,23,1).

Despite establishment of comprehensive classification system and improved understanding of the pathophysiology, definite treatment protocol has not yet been established. Several studies have reported case series with a complex or ambiguous injury mechanism including terrible triad injury or olecranon fracture dislocation, not pure VPMRI (12,18,16,19). The results of these studies can be confusing to the precise outcomes after treatment for pure VPMRI. The aim of this study was to investigate radiographic findings, treatments, and outcomes of a large series of VPMRI and to propose its treatment guideline. This study was conducted to confirm the hypothesis that decisions regarding treatment of VPMRI should be made on a case-by-case basis depending on the pattern of the coronoid fragment and the degree of ligamentous injuries.

2. Materials and Methods

This paper was approved by the institutional review board of Dongsan hospital (IRB No: 2023-02-014).

This multicenter retrospective cohort study included 91 patients with pure VPMRI who were received treatment at 6 hospitals between 2006 and 2021. Inclusion criteria included patients with 1) confirmed AMCF fracture (anteromedial type according to O'Driscoll classification) by plain radiographs and 3-dimensional (3D) computed tomography (CT) at the time of initial injury, 2) referred ≤ 3 weeks after initial injury, and 3) follow-up period ≥ 12 months after treatment. Exclusion criteria were as follows: 1) elbow fracture combined with olecranon fracture or radial head fracture, 2) patients with follow-up data that was incomplete, and 3) patients who underwent surgery after ≥ 3 weeks after injury.

All cases were initially diagnosed as an AMCF fracture by plain radiographs and 3D-CT performed in the emergency department or outpatient clinic. In cases involving elbow dislocation, surgeons tried to evaluate stability after closed reduction. Examination for elbow instability was performed using a gravity varus test or stress test under fluoroscopy with anesthesia or without anesthesia. If the elbow was stable, gentle passive range of motion (ROM) exercise was started after plaster immobilization over a period of 2 to 4 weeks. If the joint was unstable including elbow subluxation or gross instability, operative treatment was performed.

Based on plain radiographs and 3D-CT, AMCF fractures were divided according to the O'Driscoll classification system (6). Measurement of number, size, and displacement of the fragment was also performed.

Magnetic resonance image (MRI) scans from 71 patients were available for assessment of the patterns of soft tissue injuries. Radiographic assessment with definite diagnosis for pure VPMRI was performed with consensus by two experienced elbow surgeons.

Operative treatment was administered according to the decision of each elbow surgeon at 6 hospitals. If the varus stress test was positive during examination under anesthesia or static ulnohumeral subluxation was seen in images, AMCF fracture was fixed using medial open approach or arthroscopic technique. If any residual varus instability without firm end point or ulnohumeral joint incongruency exists after AMCF fixation, LCL complex was repaired. Repair of the medial collateral ligament (MCL) was performed using a suture anchor when the MCL injury was observed during AMCF fragment fixation. If AMCF fragment was small or minimally displaced, surgeons performed varus stress test under fluoroscopy and assessed the end feeling and joint congruency. If the end feeling was firm and the medial ulnohumeral joint was congruent, surgeons chose nonoperative treatment. If not, LCL complex was repaired. After immobilization for 1 to 4 weeks after surgery, gentle passive ROM exercise was started.

The mean follow-up period was 46.8 months (range, 12-192 months). Evaluation of clinical outcomes was performed using the visual analogue scale (VAS) pain score, the Mayo elbow performance score (MEPS) (26), the Quick Disabilities of the Arm, Shoulder and Hand (Quick-DASH) score (27), and active ROM. Evaluation of radiographic outcomes including joint congruity, heterotopic ossification using the Hastings and Graham classification (28), or posttraumatic arthritic change using the Bromberg and Morrey grading system (29) was based on serial plain radiographs. Assessment of complications was also performed.

IBM SPSS ver. 25.0 (IBM Co., Armonk, NY, USA) was used in performance of data analyses. Pearson correlation coefficients, one-way analysis of variance, and t-test were used to assess the correlation between variables and final clinical outcomes. Mann-Whitney U test, chi-square test, and linear by linear association were used to assess the effect of variables between operative and nonoperative groups. The level of significance was set at $p < 0.05$.

3. Results

The mean age of the patients was 43.0 ± 14.0 years (range, 16 to 71 years); there were 72 males (79.1%) and involvement of the left elbow was observed in 60 patients (65.9%). Nineteen patients (20.9%) were associated with elbow dislocation.

Regarding coronoid fractures, there were 4 cases (4.4%) of anteromedial subtype 1, 67 cases (73.6%) of subtype 2, and 20 cases (22.0%) of subtype 3. Regarding the number of coronoid fragment, there were 42 cases (46.1%) involving a single fragment, 27 cases (29.7%) involving 2 fragments, and 22 cases (24.2%) involving ≥ 3 fragments. Mean size of coronoid fragment was 12.8 ± 5.4 mm (range, 4 to 25 mm). Mean displacement of coronoid fractures was 5.3 ± 4.1 mm (range, 0 to 20 mm). On MRI, complete tear of the LCL was observed in 83.1% (59/71 cases) and partial tear or strain of the LCL in 16.9% (12/71 cases). Complete tear of the MCL was observed in 33.8% (24/71 cases) and partial tear or strain of the MCL in 60.6% (43/71 cases). Normal MCL was observed in 5.6% (4/71 cases).

Operative treatment was administered in 68 cases (74.7%) and non-operative treatment was administered in 23 cases (25.3%). The mean time until operation was 5.1 ± 3.8 days (range, 1 to 20 days). In 68 cases who received operative treatment, both side fixation was performed in 40 cases (58.8%), medial side fixation only in 17 cases (25.0%), and lateral side fixation only using a suture anchor in 11 cases (16.2%). Fixation of AMCF fractures was performed using open medial approach (49 cases) and arthroscopic assisted technique (5 cases). Fixation methods included plate (27 cases), screw (9 cases), K-wire tension band (7 cases), K-wire (6 cases), suture anchor (4 cases), pullout suture (1 cases), or combination. Additional MCL repair was performed in 15 cases and MCL repair without AMCF fixation was performed in 3 cases.

At the final follow-up, the mean VAS pain score was 0.9 ± 1.4. The mean MEPS was 93.7 ± 12.2 and 67 cases (73.6%) were graded as excellent, 19 cases (20.9%) as good, 3 cases (3.3%) as fair, and 2 cases (2.2%) as poor. The mean Quick-DASH score was 7.9 ± 15.6 and 72 cases (79.1%) were graded as excellent, 10 cases (11.0%) as good, 5 cases (5.5%) as fair, and 4 cases (4.4%) as poor. The mean final ROM was 135.4 ° ± 11.8 ° of flexion, 5.1 ° ± 9.0 ° of extension, 77.5 ° ± 9.2 ° of pronation, and 82.0 ° ± 9.0 ° of supination.

Regarding correlation between variables and final clinical outcomes, arthritic change and heterotopic ossification after operative or nonoperative treatment were significantly associated with final VAS pain score, MEPS, and Quick-DASH score (Table 1). In the operative group, longer time until operation was significantly associated with VAS pain score and Quick-DASH score (Table 2).

Twenty patients (22.0%) experienced complications after treatment including hardware irritation in 6 cases, elbow stiffness in 6 cases, ulnar neuropathy in 5 cases, arthritic change with recurrent instability in 1 case, screw penetration into the joint in 1 case, and cubitus varus in 1 case. Reoperation was performed in 14 cases (15.4%).

Regarding correlation between variables and treatments, no significant differences in final clinical scores and ROMs were observed between operative and nonoperative groups, however, significant differences were observed with regard to the number of fragments ($p < 0.05$), displacement (5.9 mm vs 3.5 mm, $p < 0.01$), and complication rate (27.9% vs 4.3%, $p < 0.001$) (Table 3).

Table 1. Correlation between Variables and Final Clinical Outcomes in All Patients

Variables	VAS pain score		MEPS		Quick DASH score	
	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value
Age	0.156	> 0.05	-0.173	> 0.05	0.097	> 0.05
Sex		> 0.05		> 0.05		> 0.05
Male (72)	0.9 ± 1.3		94.4 ± 10.5		7.6 ± 14.7	
Female (19)	1.0 ± 1.5		91.3 ± 16.7		9.4 ± 17.8	
Side		> 0.05		> 0.05		> 0.05
Left (60)	0.9 ± 1.3		93.3 ± 12.8		8.8 ± 16.9	
Right (31)	0.9 ± 1.5		94.7 ± 10.6		6.3 ± 17.7	
Combined injury		> 0.05		> 0.05		> 0.05
Yes (15)	1.5 ± 1.4		91.0 ± 11.4		17.2 ± 24.1	
No (76)	0.8 ± 1.3		94.3 ± 12.1		6.1 ± 12.4	
Dislocation		> 0.05		> 0.05		> 0.05
Yes (19)	1.2 ± 1.7		94.0 ± 12.1		8.3 ± 14.0	
No (72)	0.8 ± 1.2		93.7 ± 12.1		7.8 ± 15.8	
Operation		> 0.05		> 0.05		> 0.05
Yes (68)	0.9 ± 1.3		93.8 ± 12.4		8.1 ± 15.5	
No (23)	0.8 ± 1.4		93.7 ± 11.1		7.3 ± 15.3	
Arthritic change		< 0.001*		< 0.001*		< 0.001*
Normal (72)	0.7 ± 1.0		95.5 ± 8.1		6.2 ± 11.5	
Mild (16)	0.9 ± 1.3		91.9 ± 12.8		8.9 ± 17.2	
Moderate (2)	3.5 ± 5.0		77.5 ± 31.8		29.6 ± 41.8	
Severe (1)	6.0 ± 0.0		30.0 ± 0.0		75.0 ± 0.0	

Variables	VAS pain score		MEPS		Quick DASH score	
	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value
Heterotopic ossification		< 0.001*		< 0.001*		< 0.001*
None (79)	0.7 ± 1.0		95.1 ± 8.6		6.2 ± 11.2	
1 (9)	0.9 ± 1.7		92.2 ± 13.7		8.8 ± 22.4	
2A (3)	5.0 ± 2.7		61.7 ± 35.5		50.0 ± 30.6	
O'Driscoll anteromedial subtype		> 0.05		> 0.05		> 0.05
1 (4)	0.5 ± 1.0		95.0 ± 10.0		3.4 ± 1.7	
2 (97)	0.9 ± 1.2		94.6 ± 11.8		13.4 ± 1.6	
3 (20)	1.1 ± 1.7		90.5 ± 13.1		21.2 ± 4.7	
Number of coronoid fragment		> 0.05		> 0.05		> 0.05
1 (42)	1.0 ± 1.1		94.1 ± 8.9		7.0 ± 9.4	
2 (27)	0.7 ± 1.3		93.3 ± 15.1		8.4 ± 19.7	
≥ 3 (22)	1.0 ± 1.8		93.6 ± 13.5		9.2 ± 18.8	
Size of coronoid fragment	0.109	> 0.05	-0.091	> 0.05	0.174	> 0.05
Displacement of coronoid fracture	-0.088	> 0.05	0.141	> 0.05	-0.036	> 0.05
Union of coronoid fracture		> 0.05		> 0.05		> 0.05
Yes (74)	0.8 ± 1.2		94.7 ± 9.8		6.3 ± 10.2	
No (17)	1.2 ± 1.8		89.4 ± 18.4		15.3 ± 27.8	

DASH: disabilities of the arm, shoulder and hand ; M: mean ; MEPS: mayo elbow performance score ; SD: standard deviation ; VAS: visual analogue scale

*: Statistically significant ($p < 0.05$).

Table 2. Correlation Between Variables and Final Clinical Outcomes in the Operative Group

Variables	VAS pain score		MEPS		Quick DASH score	
	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value
Age	0.229	> 0.05	-0.220	> 0.05	0.190	> 0.05
Sex		> 0.05		> 0.05		> 0.05
Male (55)	0.8 ± 1.2		94.7 ± 10.0		7.0 ± 13.9	
Female (13)	1.4 ± 1.7		89.6 ± 19.5		13.0 ± 20.7	
Side		> 0.05		> 0.05		> 0.05
Left (41)	0.9 ± 1.2		93.7 ± 13.3		8.8 ± 17.3	
Right (27)	1.0 ± 1.5		93.9 ± 11.1		7.1 ± 12.3	
Combined injury		> 0.05		> 0.05		> 0.05
Yes (12)	1.3 ± 1.0		93.3 ± 7.8		15.2 ± 21.4	
No (56)	0.8 ± 1.4		93.8 ± 13.2		6.6 ± 13.6	
Dislocation		> 0.05		> 0.05		> 0.05
Yes (16)	1.1 ± 1.8		93.8 ± 12.8		8.7 ± 14.9	
No (52)	0.8 ± 1.2		93.8 ± 12.4		8.0 ± 15.8	
Arthritic change		< 0.001*		< 0.001*		< 0.001*
Normal (51)	0.8 ± 1.0		95.7 ± 7.9		7.1 ± 12.7	
Mild (14)	0.6 ± 0.8		93.6 ± 10.1		4.2 ± 6.5	
Moderate (2)	3.5 ± 5.0		77.5 ± 31.8		29.6 ± 41.8	
Severe (1)	6.0 ± 0.0		30.0 ± 0.0		75.0 ± 0.0	
Heterotopic ossification		< 0.001*		< 0.001*		< 0.001*
None (59)	0.8 ± 0.9		95.0 ± 8.6		6.7 ± 12.1	
1 (6)	0.1 ± 0.4		97.5 ± 6.1		1.5 ± 2.8	
2A (3)	5.0 ± 2.7		61.7 ± 35.5		50.0 ± 30.6	

Variables	VAS pain score		MEPS		Quick DASH score	
	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value	M ± SD / pearson correlation	p-value
O'Driscoll anteromedial subtype		> 0.05		> 0.05		> 0.05
1 (2)	1.0 ± 1.4		90.0 ± 14.1		3.4 ± 4.8	
2 (51)	0.9 ± 1.2		94.6 ± 12.1		6.7 ± 12.3	
3 (15)	1.0 ± 1.8		91.3 ± 13.6		13.7 ± 23.7	
Number of coronoid fragment		> 0.05		> 0.05		> 0.05
1 (26)	1.1 ± 1.0		94.4 ± 8.8		8.0 ± 10.0	
2 (23)	0.8 ± 1.4		92.2 ± 16.1		9.8 ± 21.0	
≥ 3 (19)	0.8 ± 1.7		94.7 ± 12.0		6.3 ± 14.2	
Size of coronoid fragment	0.010	> 0.05	-0.051	> 0.05	0.216	> 0.05
Displacement of coronoid fracture	-0.144	> 0.05	0.208	> 0.05	-0.053	> 0.05
Union of coronoid fracture		> 0.05		> 0.05		> 0.05
Yes (58)	0.9 ± 1.2		94.6 ± 10.1		6.4 ± 10.7	
No (10)	1.2 ± 1.9		89.0 ± 21.7		18.0 ± 30.6	
Time until operation	0.274	< 0.05*	-0.113	> 0.05	0.259	< 0.05*
Surgical fixation		> 0.05		> 0.05		> 0.05
Both (39)	1.2 ± 1.4		93.7 ± 10.9		10.1 ± 15.9	
Medial side only (17)	0.5 ± 0.7		95.3 ± 8.6		3.2 ± 7.2	
Lateral side only (12)	0.8 ± 1.8		91.7 ± 20.3		8.8 ± 21.3	

DASH: disabilities of the arm, shoulder and hand ; M: mean ; MEPS: mayo elbow performance score ; SD: standard deviation ; VAS: visual analogue scale

*: Statistically significant ($p < 0.05$).

Table 3. Correlation between Variables and Treatments

Variables	Operative treatment (68) M ± SD / N (%)	Nonoperative treatment (23) M ± SD / N (%)	p-value
Age	42.5 ± 14.2	44.4 ± 13.8	> 0.05
Sex			> 0.05
Male	55 (76.4)	17 (23.6)	
Female	13 (68.4)	6 (31.6)	
Side			> 0.05
Left	41 (68.3)	19 (31.7)	
Right	27 (87.1)	4 (12.9)	
Combined injury			> 0.05
Yes	12 (80.0)	3 (20.0)	
No	56 (73.7)	20 (26.3)	
Dislocation			> 0.05
Yes	16 (84.2)	3 (15.8)	
No	52 (72.2)	20 (27.8)	
Arthritic changes			> 0.05
Normal	51 (70.8)	21 (29.2)	
Mild	14 (87.5)	2 (12.5)	
Moderate	2 (100.0)	0 (0.0)	
Severe	1 (100.0)	0 (0.0)	
Heterotopic ossification			> 0.05
None	59 (74.7)	20 (25.3)	
1	6 (66.7)	3 (33.3)	
2A	3 (100.0)	0 (0.0)	

Variables	Operative treatment (68) M ± SD / N (%)	Nonoperative treatment (23) M ± SD / N (%)	p-value
O'Driscoll anteromedial subtype			> 0.05
1	2 (50.0)	2 (50.0)	
2	51 (76.1)	16 (23.9)	
3	15 (75.0)	5 (25.0)	
Number of coronoid fragment			< 0.05*
1	26 (61.9)	16 (38.1)	
2	23 (85.2)	4 (14.8)	
≥ 3	19 (86.4)	3 (13.6)	
Size of coronoid fragment (mm)	13.0 ± 5.3	12.1 ± 5.9	> 0.05
Displacement of coronoid fragment (mm)	5.9 ± 4.1	3.5 ± 3.4	< 0.01*
Union of coronoid fracture			> 0.05
Yes	58 (78.4)	16 (21.6)	
No	10 (58.8)	7 (41.2)	
Complication	19 (27.9)	1 (4.3)	< 0.001*

M: mean ;N: number ; SD: standard deviation
*: Statistically significant ($p < 0.05$).

4. Discussion

The current study revealed that VPMRI is a challenging injury that involves AMCF fracture and ligamentous injuries. Depending on the pattern of the coronoid fragment and the degree of the ligamentous injuries, operative treatment of unstable VPMRI using various fixation techniques including coronoid fixation and ligamentous repair yielded satisfactory final clinical outcomes. Stable VPMRI with AMCF fracture involving minimal displacement or small number of fragments can be treated nonoperatively. However, surgeons should be aware of the high complication (22.0%) and reoperation rates (15.4%) after operative treatment. Longer time until operation, arthritic change, and heterotopic ossification after treatment were significantly associated with poor clinical outcomes.

VPMRI have been known to involve AMCF fracture and lateral ligamentous injury (3,1,10). While LCL injury is commonly associated with this type of fracture, it has recently been recognized that associated MCL injury is more common than previously determined (28,7,16). According to the findings of a biomechanical study reported by Hwang et al. (30), the posterior bundle of the MCL should be disrupted for gross elbow subluxation in the presence of an AMCF fracture and the LCL injury. Klug et al. (16) reported a relatively high rate of MCL injury (33%) in the context of AMCF fracture. Park et al. (7) reported 6 (54.5%) of 11 cases had concomitant MCL injury, including 2 cases with an avulsion fracture of the humeral site. On MRI analysis in the current study, complete tear of LCL was observed in 83.1% (59/71 cases) and complete tear of MCL was observed in 33.8% (24/71 cases). These findings indicated that an AMCF fracture can occur by rotational force as well as varus force and concomitant MCL injury might be associated with joint subluxation or dislocation. If the elbow is unstable after AMCF fixation and LCL repair, concomitant MCL injury should be addressed.

The size, displacement, and configuration of the AMCF fragment as well as associated ligamentous injuries are likely to be critical in the decision-making process for proper treatment. Despite an improved understanding of VPMRI, no standard treatment protocol and technique have been established. Subsequently, there has been little documentation of treatments, outcomes, and prognosis in patients with VPMRI. A study reported by Pollock et al. (21) in 2009 proposed operative guidelines for AMCF fractures and found that the size of AMCF fragment influences the elbow kinematics under varus stress. They recommended that small fragment < 5 mm (subtype 1) can be treated with LCL repair only, whereas larger fragments (subtype 2 and 3) may require AMCF fragment fixation and LCL repair. Park et al. (7) reported that AMCF fractures were treated in accordance with the guidelines reported by Pollock et al. including LCL repair only for subtype 1 fracture (2 cases) and buttress plating with LCL repair for subtype 2 (4 cases) and subtype 3 (5 cases) fractures. They reported that 10 of 11 patients had good to excellent results without residual instability. In 2014, Rhyou et al. (8) suggested an algorithm for management of AMCF fractures according to fragment size. The cutoff value established for open reduction and internal fixation was 5 mm. They concluded that, in the case of subtype 1 or 2 fractures with the fragment size of < 5 mm, LCL repair only seems to be sufficient because small and comminuted fragments may be difficult to achieve sufficient stability by open reduction and internal fixation. Syed et al. (19) reported that AMCF fractures with s fragment size > 6.5 mm are likely to be more unstable and require operation. Numerous studies have advocated that most AMCF fractures require operative fixation to prevent residual instability and post-traumatic ulnohumeral arthritis. The AMCF fractures can be fixed using a buttress plate, screw, K-wire, suture anchor, transosseous suture, and these combinations depending on configuration of the fracture fragment. Although good clinical and radiographic results after operative treatment have been reported, it is still unclear whether operative treatment in patients with VPMRI is always beneficial. Several recent studies have reported that VPMRI in certain circumstance can be treated nonoperatively with satisfactory clinical and radiographic results (25,24,22,23). Chan et al. (22) reported 10 cases (9 subtype 2 and 1 subtype 3) treated nonoperatively for small or minimally displaced fractures with no evidence of elbow subluxation and found satisfactory clinical and radiographic results. Moon et al. (24) stable VPMRI can be treated successfully with nonoperative treatment because minimally displaced fragment has a function of bony stability with surrounding soft tissues.

Lanzerath et al. (5) reported a systematic review for the treatment of AMCF fracture including 10 studies (128 cases). One hundred and fourteen patients (89.1%) were treated operatively and 14 patients (10.9%) were treated nonoperatively. Among the patients who underwent operative treatment, 70.2% had concomitant LCL repair with AMCF fragment fixation or LCL repair only. The mean MEPS was 91.5 in patients with operative treatment and 91.4 in patients with conservative treatment. Reoperation was required in 10 patients (7.8%). In the current study, operative treatment was administered in 68 cases (74.7%) including both side fixation in 40 cases (58.8%), medial side fixation only in 17 cases (25.0%), and lateral side fixation only in 11 cases (16.2%) (Figure 1). Nonoperative treatment was administered in 23 cases (25.3%) (Figure 2). Cases involving a smaller number or lesser displacement of the AMCF fragment tended to receive nonoperative treatment. Overall, the mean MEPS and Quick-DASH scores at the final follow-up were 93.7 and 7.9 without differences between operative and nonoperative groups. Longer time until operation, arthritic change, and heterotopic ossification after treatment were significantly associated with poor clinical outcomes. The overall complication and reoperation rate was 22.0% and 15.4%. A higher complication rate was observed in the operative group compared with the nonoperative group (27.9% vs 4.3%). Based on the findings of the current study, study have proposed guidelines for treatment of VPMRI (Figure 3).

The current study has several limitations. First, it is a retrospective study that did not include a control group. Second, treatment and rehabilitation might be heterogeneous because this is a retrospective multicenter study involving 6 elbow surgeons. Third, measurement of maximal fragment size and displacement on CT images may be difficult in cases with fracture comminution. Further well-designed prospective multicenter studies are required to examine clinical outcomes according to treatment options and to establish standard guidelines for treatment of VPMRI. However, it is worthy of note that this is the first multicenter study that included a large series of pure VPMRI.

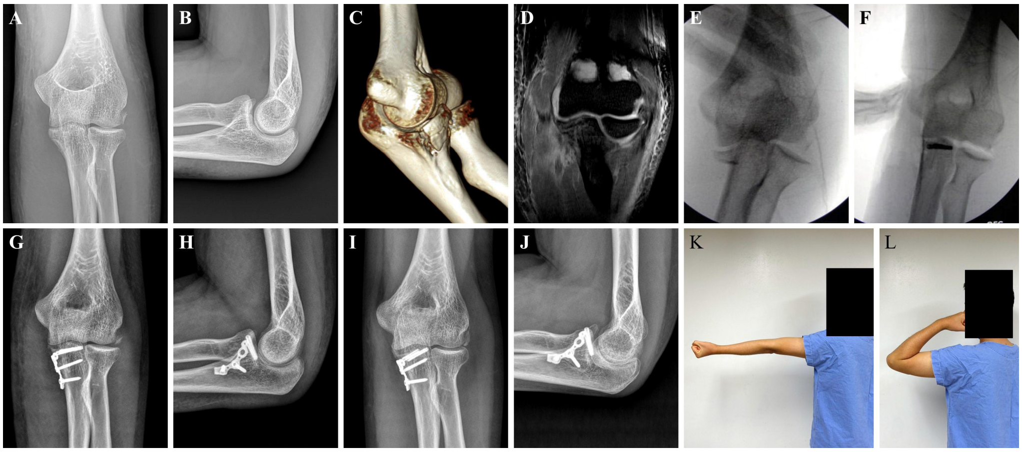

Figure 1. Case 1. VPMRI patient who treated operatively shows good outcome after 7 years. (A-D) Plain radiographs, 3D CT, and MR image show VPMRI that involves subtype 2 AMCF fracture and LCL injury. (E-H) Fluoroscopic images show that the joint is stable under varus stress test after AMCF fragment fixation. (I-L) Plain radiographs at 7 years after operation show congruent elbow joint with full range of motions. AMCF: anteromedial coronoid facet ; 3D CT: 3 dimensional computed tomography; LCL: lateral collateral ligament ; VPMRI: varus posteromedial rotatory instability.

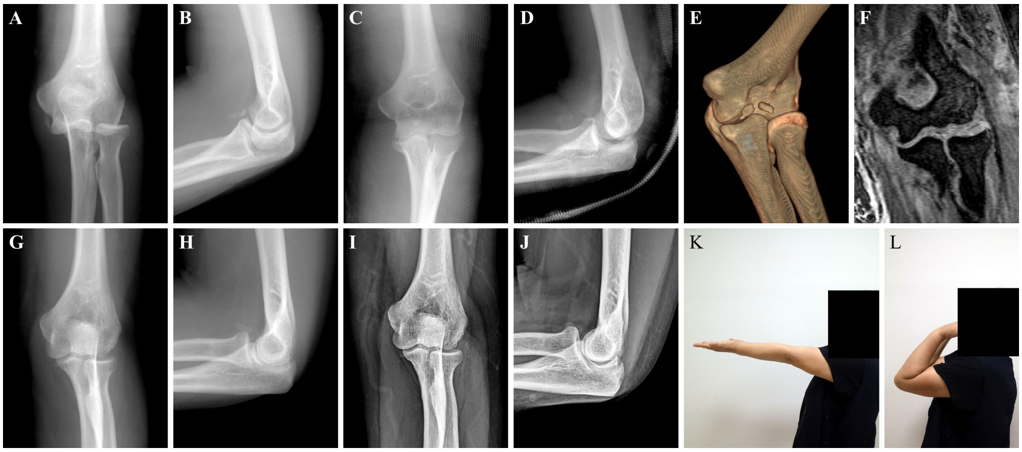

Figure 2. Case 2. VPMRI patient who treated nonoperatively shows good outcome after 15 years. (A-H) Plain radiographs, 3D CT, and MR image show VPMRI with elbow dislocation managed by nonoperative treatment. (I-L) Plain radiographs at 15 years after nonoperative treatment show congruent elbow joint with full range of motions. 3D CT: 3 dimensional computed tomography; VPMRI: varus posteromedial rotatory instability.

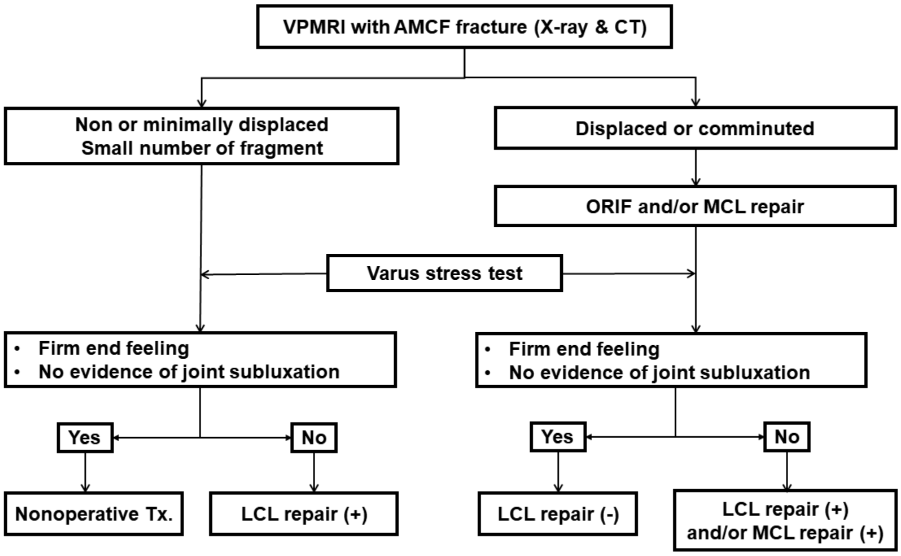

Figure 3. Treatment guidelines for VPMRI.

LCL: lateral collateral ligament ; MCL: medial collateral ligament ; ORIF: open reduction internal fixation ; VPMRI: varus posteromedial rotatory instability.

5. Summary

The aim of this study was to investigate radiographic findings, treatments, and outcomes of a large series of varus posteromedial rotatory instability (VPMRI). 91 patients with VPMRI injury were selected for analysis. Depending on the pattern of coronoid fragment and the degree of ligamentous injuries, operative treatment of unstable VPMRI using various fixation techniques including coronoid fixation and ligament repair yielded satisfactory final clinical outcomes. However, surgeons should be aware of the high complication and reoperation rates after operative treatment. Stable VPMRI with anteromedial coronoid facet fracture involving minimal displacement or small number of fragments can be treated nonoperatively. The current study is a retrospective study that did not include a control group. Further well-designed prospective multicenter studies are required to examine clinical outcomes according to treatment options and to establish standard guidelines for treatment of VPMRI.

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Pure Varus Posteromedial Rotatory Instability of the Elbow: Radiographic Findings, Treatment, and Outcomes

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(Abstract)

The aim of this study was to investigate radiographic findings, treatments, and outcomes of a large series of varus posteromedial rotatory instability (VPMRI). This study retrospectively reviewed 91 pure VPMRI cases with anteromedial coronoid facet (AMCF) fracture (O'Driscoll classification anteromedial type) which were treated at 6 hospitals. Depending on the pattern of coronoid fragment and the degree of ligamentous injuries, operative treatment of unstable VPMRI using various fixation techniques including coronoid fixation and ligament repair yielded satisfactory final clinical outcomes. However, surgeons should be aware of the high complication and reoperation rates after operative treatment. Stable VPMRI with AMCF fracture involving minimal displacement or small number of fragments can be treated nonoperatively.

내반 및 후내측 회전 손상 : 영상학적 소견, 치료 및 결과

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(초록)

본 연구는 내반 및 후내측 회전 손상의 영상학적 소견, 치료 및 결과를 분석하고 이를 통해 치료 가이드라인을 제시하고자 한다. 6개의 병원에서 91예의 O'Driscoll classification Anteromedial type을 분석하였다. 평균 추시 관찰 기간은 46.8 개월 이었다. 수술적 치료는 74.7%(68예)로 내외측 양측 고정이 57.4%(39예), 내측 고정 23.5%(16예), 외측 고정 19.1%(13예)였다. 비수술적 치료는 25.3%(23예) 이었다. Mayo Elbow Performance Score와 Quick Disabilities of the Arm의 평균은 각각 93.7 ± 12.2 및 7.9 ± 15.6 이었다. 합병증 발생률은 22.0% 재수술의 빈도는 15%였다. 골절 골편의 양상 및 외측 측부인대의 손상 정도에 따라 불안정한 내반 및 후내측 회전 손상에서 외측 혹은 내측, 양측 수술적 고정을 통하여 좋은 임상적 결과를 얻을 수 있다. 그러나 높은 합병증 발생률 및 재수술 빈도에 주의해야 한다. 적은 수의 골편 및 전위가 작은 안정한 내반 및 후내측 회전 손상의 경우 비수술적 치료로 만족할 만한 결과를 얻을 수 있다.