


CLINICAL ARTICLE

Repair Versus Non-Repair of Lateral Ulnar Collateral Ligament in Elbow Varus Posteromedial Rotatory Instability Treatment: A Comparative Study

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Objective: To compare the effects of repairing and not repairing the lateral ulnar collateral ligament (LUCL) when surgically treating elbow varus posteromedial rotatory instability (PMRI).

Methods: In this retrospective study spanning June 2014 to February 2019, 24 patients with elbow PMRI who were treated surgically were assigned to group RL (Repair LUCL) or group NL (Non-repair LUCL) depending on whether the LUCL was repaired. Hospitalization time, operation time, intraoperative blood loss, and related complications were reviewed. The elbow range of motion (ROM), the visual analog scale (VAS), the Mayo elbow performance score (MEPS), and the disabilities of the arm, shoulder, and hand (DASH) score were used for functional assessment.

Results: Among the 24 patients with PMRI, 15 were assigned to group RL and nine were assigned to group NL. The mean blood loss (184.66 ± 20.3 vs 207.33 ± 19.447 , $P < 0.001$), the operation time (98.88 ± 12.693 min vs 184.66 ± 20.3 min, $P < 0.001$) were significantly lower in group RL compared to group NL. There were no significant differences between the two groups in time until surgery and follow-up time (6.66 ± 1.838 vs 6.11 ± 1.900 days, 25.53 ± 2.099 vs 26.11 ± 2.891 months, $P = 0.577$, $P = 0.486$). All of the patients achieved bone union. The elbow flexion-extension ROM ($122.00^\circ \pm 3.162^\circ$ vs $121.11^\circ \pm 3.333^\circ$ at 12 months, $P = 0.520$) and pronation-supination ROM ($154.53^\circ \pm 3.335^\circ$ vs $155.55^\circ \pm 4.639^\circ$ at 12 months, $P = 0.537$). Both groups achieved similar results in MEPS score (90.53 ± 2.695 vs 89.77 ± 3.865 , $P = 0.578$) and DASH (9.77 ± 1.897 vs 9.99 ± 1.550 , $P = 0.772$) score at the final follow-up. And the MEPS score revealed excellent results (87% in group RL, 89% in group NL). The VAS scores decreased significantly in group RL (from 6.13 ± 0.990 to 1.93 ± 0.593) and group NL (from 5.77 ± 1.481 to 1.88 ± 0.781), and no significant differences in preoperative or final follow-up were observed between the two groups ($P = 0.487$, $P = 0.876$). Complications observed in group NL with one patient occurred cubital tunnel syndrome 3 months after the operation, the patient underwent ulnar nerve simple neurolysis and the symptoms were relieved after 3 weeks.

Conclusion: For patients with elbow PMRI, satisfactory functional outcomes can be yielded with non-repair of the LUCL as long as the stable elbow joint is performed during operation.

Key words: Elbow instability; Lateral ulnar collateral ligament; LUCL; Varus posteromedial rotatory instability; PMRI

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Disclosure: Each author certifies that they have no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Received 21 September 2020; accepted 26 August 2021

Orthopaedic Surgery 2022;14:35-43 • DOI: 10.1111/os.13146

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Introduction

The elbow is the second most commonly dislocated major joint in adults. Data show that the fracture and dislocation of elbow joint account for 15%–20% of elbow injuries^{1,2}. Many elbow injuries can lead to elbow instability. Complex elbow dislocation mechanisms may result in post-traumatic arthrosis, appearance malformation, and poor functional outcomes^{3–6}.

Varus posteromedial rotatory instability (PMRI) is proposed on the damage mechanism of posterolateral rotatory instability (PLRI), which is accompanied with an anteromedial facet fracture of the coronoid process, the lateral collateral ligament (LCL), and the posterior bundle of the medial collateral ligament (PMCL) injuries^{7,8}. Anteromedial facet fractures occur when the anterior medial facet of the coronoid process collides with the distal humerus under varus stress. The anteromedial facet of the coronoid process is prone to injury, as about 58% of it is not supported by the proximal ulnar metaphysis^{9,10}. Fracture of the coronoid process may become chronically unstable in the elbow joint. Reconstructing the articular surface and restoring the trochlear track is useful for promoting early functional exercise. Biomechanical studies suggest that coronoid tip fractures less than 2 mm may be treated nonoperatively in PMRI; otherwise, surgery is indicated¹¹.

However, there is no definite conclusion about repairing the LUCL. Many studies have shown that reconstructing the LUCL and restoring the anteromedial aspect of the coronoid fracture are helpful for facilitating early functional exercise and preventing the development of osteoarthritis. Klug *et al.* in a retrospective study of 14 patients with PMRI treated with operation found that although all fractures healed, four elbows developed heterotopic ossification and one developed grade II post-traumatic osteoarthritis¹². The authors concluded that the collateral ligaments with any associated detachment should be fixed after the stable coronoid fixation is addressed. McLean *et al.* reported that among 27 patients with LCL injury who were treated with coronoid fixation and LCL reconstruction, complications arose in 10 patients, and 4 required surgical management¹³. In addition, to reduce postoperative complications, Rashid *et al.* suggested arthroscopic fixation of the coronoid fracture and repair of the LUCL¹⁴.

Some studies have shown that not all PMRI procedures require repair of the LUCL. Rhyou *et al.* described five patients with O'Driscoll type 2 fractures (three with LUCL complete rupture, one with LUCL partial rupture, and one with the LUCL not available) treated with isolated coronoid fixation⁵. The patients reached mean MEPS 100, and no complications were found. Chen *et al.* reported a retrospective comparative study including 20 patients, wherein 17 were treated with only fixation of the coronoid fractures, and three showed greater than grade II laxity so the LCL was reconstructed⁶. The authors concluded that the anteromedial facet fractures should be thoroughly treated before the decision to repair the LCL is made. Furthermore, the tension of the LCL needs to be tested at multiple angles intraoperatively. If the surgeon is inexperienced, it is possible to keep the LCL in a tense state, which can cause iatrogenic PLRI, and patients may be

at risk of reoperation⁴. Recurrent instability was observed in 8% of cases after LUCL reconstruction¹⁵.

Therefore, we compared the efficacy and safety of repair and non-repair of LUCL when surgically treating elbow PMRI. The purpose of the study was: (i) to compare the therapeutic efficacy between repair and non-repair of LUCL on elbow PMRI; (ii) to explore the safety of non-repair of LUCL when surgically treating elbow PMRI; (iii) to provide a theoretical basis for surgical treatment of elbow PMRI.

Materials and Methods

General Information

This retrospective review included 30 patients who were treated for PMRI at Tianjin Hospital between June 2014 to February 2019. The surgery was performed by the same physician. The patients underwent the specific physical examinations that we usually perform, the gravity-assisted varus stress test, and posteromedial impingement test in the subacute setting, and MCL or LUCL injuries were often identified using magnetic resonance imaging (MRI). Patients were assigned to group A (repair) or group B (non-repair) depending on whether repair of the LUCL was included in their treatment. The O'Driscoll classification⁷ of coronoid fractures was used in all of the patients. This study protocol was approved by the ethics committee at Tianjin Hospital, and all of the patients signed an informed consent form.

The inclusion criteria were as follows: (i) patients with coronoid fracture combined with the LUCL injuries; (ii) patients with surgical treatment of the coronoid fracture; (iii) the patients received repair of the LUCL or non-repair; (iv) the related outcomes were comprehensively recorded and compared.

The exclusion criteria were as follows: (i) elbow fracture combined with ulnar olecranon fracture or radial head fracture; (ii) open fracture; (iii) patients with follow-up data that was incomplete or did not cooperate with treatment; (iv) the time from injury to operation was more than 3 weeks.

Surgical Technique

Anesthesia and Position

All the operations were conducted with the patients under brachial plexus anesthesia or general anesthesia. The affected elbow was laid on an arm table in the supine position, and a pneumatic tourniquet was applied.

Approach and Exposure

Surgical exposure was performed through the Hotchkiss approach to achieve fixation of the coronoid fracture and the Kocher approach to repair the LUCL.

Reconstruct the Coronoid Fracture

The coronoid fracture was exposed using the Hotchkiss approach by splitting the flexor carpi radialis and pronator teres. According to the size of the fracture fragments, a corresponding suture anchor, cannulated screw, and plate

were selected to reconstruct the coronoid process, and then a nonabsorbable suture was used to repair the anterior capsule to recover the anterior column.

Evaluate the Stability of the Elbow Joint

An X-ray was taken in the extension-supination position and 30° flexion position during operation. It was determined that the LUCL needed to be repaired if the X-ray showed subluxation or dislocation in the humeroradial joint; otherwise, the LUCL did not need to be reconstructed.

Repair the LUCL

For patients in group RL, as it was found that the LUCL needed to be repaired, the above surgical procedure was then followed by a Kocher approach to separate the extensor carpi ulnaris and anconeus. The LUCL was avulsed from the supralateral condyle, and then it was repaired with sutures from the suture anchor, which was inserted in the humeral origin to protect the joint from subluxation or dislocation. Furthermore, the ligament was fixed at the anterior and superior part of the origin as this helps tighten the LUCL to facilitate early functional exercise. Then an X-ray was taken once again. Finally, the internal fixation and ligament repair were checked, and the stability of the elbow joint was evaluated (Fig 1).

Postoperative Management

All of the patients were administered an intravenous antibiotic after surgery (routine for 3 days). The drainage tube was pulled out 1–2 days after operation. Rehabilitation exercise was performed with the protection of a brace on the second

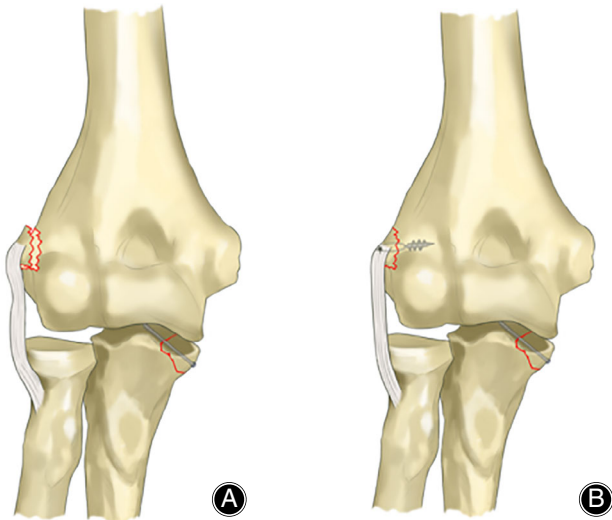


Fig 1 Schematic drawings for the surgical technique. (A) Surgical diagram of group NL with reconstruct the anteromedial facet coronoid fracture. (B) Surgical diagram of group RL with reconstruct the anteromedial facet coronoid fracture and repair of the lateral ulnar collateral ligament.

day after operation to prevent postoperative elbow stiffness. Postoperative elbow protective brace fixation was prescribed for 2 weeks, allowing passive elbow flexion and extension dependent on the weight of the forearm. Active rehabilitation exercises were performed for 3–6 weeks, but resistance training was avoided. We recommended allowing early ROM in the postoperative period and limiting the period of immobilization as much as possible. Oral administration of indomethacin for 4 weeks was prescribed to prevent ossifying myositis of the elbow joint.

Evaluation Index

The pre- and postoperative elbow X-ray film were used to observe fracture healing. We also recorded operative details, clinical results, and patients' discomfort in daily life. Mayo elbow performance score¹⁶ (MEPS), visual analog scale¹⁷ (VAS), disabilities of the arm, shoulder, and hand score¹⁸ (DASH), and the elbow range of motion (ROM) were used for functional evaluation.

Mayo Elbow Performance Score (MEPS)

MEPS is widely used for evaluation of the elbow clinical outcomes. It consists of four parts: pain, motion, stability, and the rating of daily function. The scale ranges from 0–100, a score ≥ 90 as excellent, 75–89 as good, 60–74 as fair, and a score <60 as poor.

Visual Analog Scale (VAS)

VAS is the most commonly used scale to evaluate a patient's level of the pain. A 10-cm continuous horizontal line is usually used to score the severity of pain. The scale is commonly graded from 0 (no pain) to 10 (maximal imaginable pain). A score of 1–3 is mild pain, 4–6 moderate is pain, and 7–9 is intense pain.

Disabilities of the Arm, Shoulder, and Hand Score (DASH)

The DASH score consists of 30 items, which are intended to evaluate upper extremity disorders. Each item is divided into five corresponding options. The lower the score, the better the function.

Range of Motion (ROM)

The ROM of the elbow should be measured at stand upright and anteflect the shoulder to 90° positions. A standard goniometer records the maximum angle at extension, flexion, pronation, and supination. The normal flexion-extension ROM ranges from about 0° to 145°–150°, and the normal pronation-supination ROM range is around 80° and 90°.

Statistical Analysis

Statistical analyses were processed with SPSS Statistics 26.0 software (SPSS Inc., Chicago, IL).

The measurement data were presented as mean \pm standard deviation, and the differences between groups were evaluated by using an independent *t*-test. The enumeration data were

described as percentages (%). Fisher's exact test or chi-square test were utilized to test the differences between proportions. A two-tailed P -value < 0.05 was considered statistically significant.

Result

General Results

Between 2014 and 2019, 30 patients with PMRI were admitted to our institution for treatment. These patients were considered for inclusion in the present study, but a total of eight patients were excluded: one had a refracture of the elbow owing to a fall injury, four were lost to follow-up, and one died from causes unrelated to surgery.

Twenty-four patients were finally enrolled in the study, with 15 patients (11 males and four females) assigned to group RL, and nine patients (six males and three females) assigned to group NL. The mean follow-up period was 25.53 ± 2.099 months in group RL, 26.11 ± 2.891 months in group NL. No statistically significant differences in age, gender, affected side, injury mechanism, time until surgery, hospitalization time, or follow-up time

were found between the two groups ($P > 0.05$). Demographic data on the two groups are summarized in Table 1.

Intraoperative Results

The mean duration of surgery was significantly lower in group NL (98.88 ± 12.693 min) compared to that of group RL (184.66 ± 20.3 min, $P < 0.001$), with a mean improvement of 85.78 min. In addition, mean blood loss was significantly lower in group NL (105.55 ± 13.333) compared to group RL (207.33 ± 19.447 , $P < 0.001$), with a mean improvement of 101.78. The operative details and data regarding hospitalization are presented in Table 2.

Postoperative Results

Range of Motion

At the 12 months follow-up, there was similar average extension, flexion in the two groups (extension $6.33^\circ \pm 2.288^\circ$ vs $7.77^\circ \pm 3.632^\circ$, $P = 0.242$, flexion $128.33^\circ \pm 3.086^\circ$ vs 128.88°

TABLE 1 Demographics of patients with PMRI whose treatment included repair or non-repair of LUCL

Variables	Group RL (n = 15)	Group NL (n = 9)	P-value
Age (years)	40.26 ± 9.121	37.22 ± 13.056	0.508 ^{&}
Gender (male/female)	11/4	6/3	0.728 [*]
Affected side(left/right)	5/10	2/7	0.562 [*]
Mechanism			
Fall	9(60%)	5(56%)	0.831 [*]
Sporting accident	3(20%)	2(22%)	0.897 [*]
Machine	1(7%)	1(11%)	0.703 [*]
Traffic accident	2(13%)	0(0%)	0.253 [*]
Others	0(0%)	1(11%)	0.187 [*]
Time until surgery (days)	6.66 ± 1.838	6.11 ± 1.900	0.577 ^{&}
Follow-up time (months)	25.53 ± 2.099	26.11 ± 2.891	0.486 ^{&}

LUCL, lateral ulnar collateral ligament; Group RL(repair LUCL); Group NL(non-repair LUCL).; [&]Independent t-test.; ^{*}Fisher's exact test or chi-square test; The P -value shown is for inter-group comparison

TABLE 2 Comparison of clinical results between group RL and group NL

Variables	Group RL (n = 15)	Group NL (n = 9)	P-value
Hospitalization time (days)	10.73 ± 2.576	11.44 ± 2.006	0.487 ^{&}
Operation time (minutes):	184.66 ± 20.3	98.88 ± 12.693	<0.001 ^{&}
Blood loss (ml)	207.33 ± 19.447	105.55 ± 13.333	<0.001 ^{&}
ROM(12 months post-op)			
Extension	$6.33 \pm 2.288^\circ$	$7.77 \pm 3.632^\circ$	0.242 ^{&}
Flexion	$128.33 \pm 3.086^\circ$	$128.88 \pm 2.204^\circ$	0.642 ^{&}
Flexion-extension	$122.00 \pm 3.162^\circ$	$121.11 \pm 3.333^\circ$	0.520 ^{&}
Pronation	$74.20 \pm 2.305^\circ$	$74.44 \pm 3.004^\circ$	0.824 ^{&}
Supination	$80.33 \pm 2.968^\circ$	$81.11 \pm 3.333^\circ$	0.559 ^{&}
Pronation-supination	$154.53 \pm 3.335^\circ$	$155.55 \pm 4.639^\circ$	0.537 ^{&}
Complication			
Ulnar nerve symptoms	0	1	0.187 [*]

Group RL(repair LUCL); Group NL(non-repair LUCL); ROM: range of motion; [&]Independent t-test. ^{*}Fisher's exact test or chi-square test; The P -value shown is for inter-group comparison.

$\pm 2.204^\circ$, $P = 0.642$), and there was similar average pronation, supination in the two groups (pronation $74.20^\circ \pm 2.305^\circ$ vs $74.44^\circ \pm 3.004^\circ$, $P = 0.824$, supination $80.33^\circ \pm 2.968^\circ$ vs $81.11^\circ \pm 3.333^\circ$, $P = 0.559$) (Fig 2).

There were no significant differences in flexion-extension and pronation-supination between the two groups (flexion-extension $122.00^\circ \pm 3.162^\circ$ vs $121.11^\circ \pm 3.333^\circ$, $P = 0.520$, pronation-supination $154.53^\circ \pm 3.335^\circ$ vs $155.55^\circ \pm 4.639^\circ$, $P = 0.537$) (Fig 3).

Mayo Elbow Performance Score (MEPS)

The results were classified in group RL as excellent in 13 cases, good in two, with the average MEPS being 90.53 ± 2.695 . The

results were classified in group NL as excellent in eight cases, good in one, with the average MEPS as 89.77 ± 3.865 . There were no significant differences in MEPS between the two groups ($P = 0.578$).

Disabilities of the Arm, Shoulder, and Hand Score (DASH)

There were no significant differences in DASH score between group RL (9.77 ± 1.897) and group NL (9.99 ± 1.550 , $P = 0.772$).

Visual Analog Scale (VAS)

The VAS decreased significantly in group RL (from 6.13 ± 0.990 to 1.93 ± 0.593) and group NL (from 5.77 ± 1.481

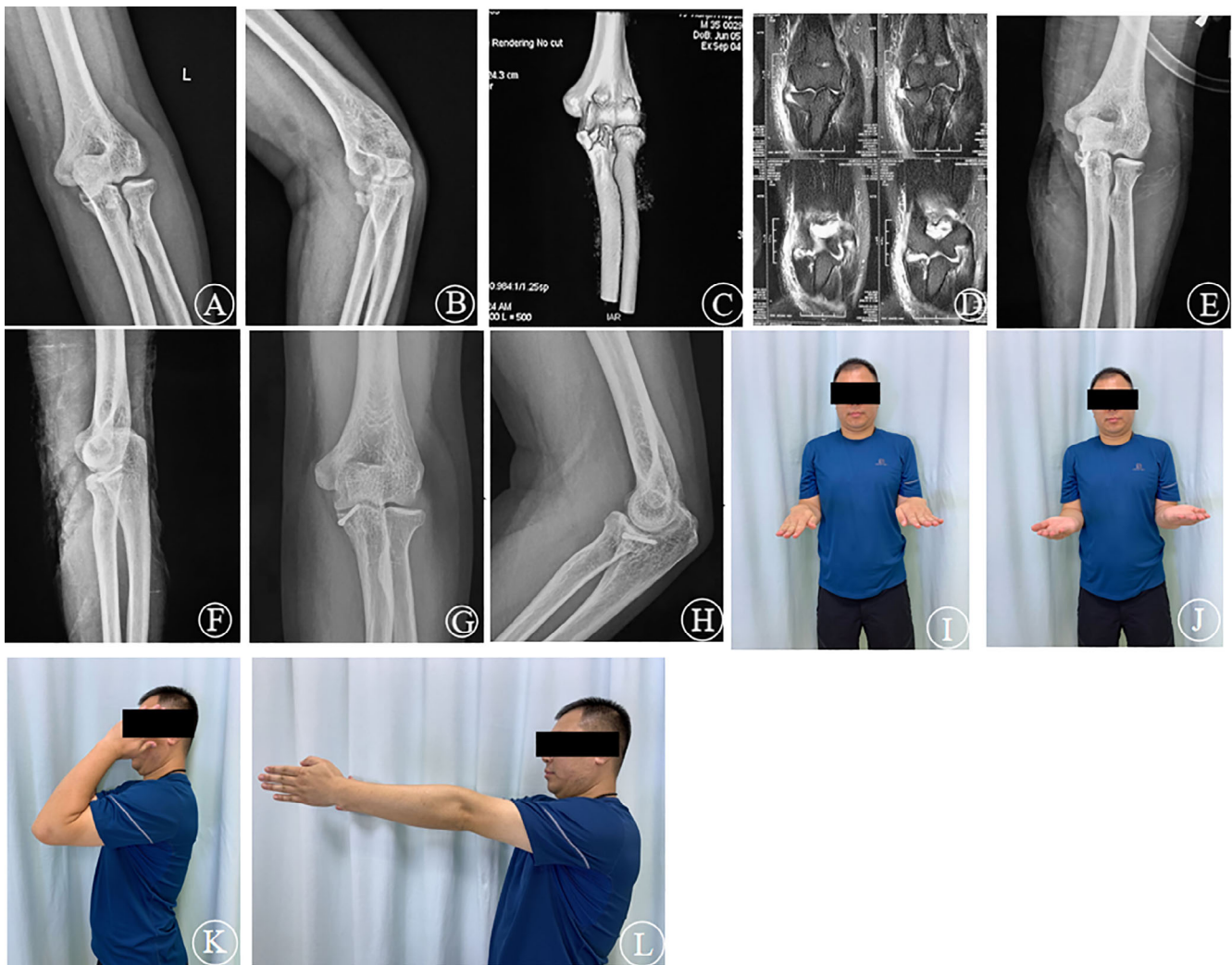


Fig 2 A 35-year-old male who had a left elbow varus posteromedial rotatory instability (PMRI) due to a bad fall. (A, B) The preoperative antero-posterior and lateral X-rays showed a anteromedial facet coronoid fracture. (C) The anteromedial facet coronoid fractures were shown in 3D reconstruction. (D) The magnetic resonance imaging (MRI) revealed complete rupture of the lateral ulnar collateral ligament (LUCL). (E) The coronoid fractures were treated with a screw fixation and the intraoperative antero-posterior X-ray showing equal space between the medial and lateral joint space. (F) The intraoperative lateral X-ray was taken in the extension-supination position and showed no subluxation or dislocation in the elbow joint. (G, H) The antero-posterior and lateral X-ray of the elbow at postoperative 26 months. (I, J) The appearance of the elbow pronation and supination at postoperative 26 months. (K, L) The appearance of the elbow flexion and extension at postoperative 26 months.

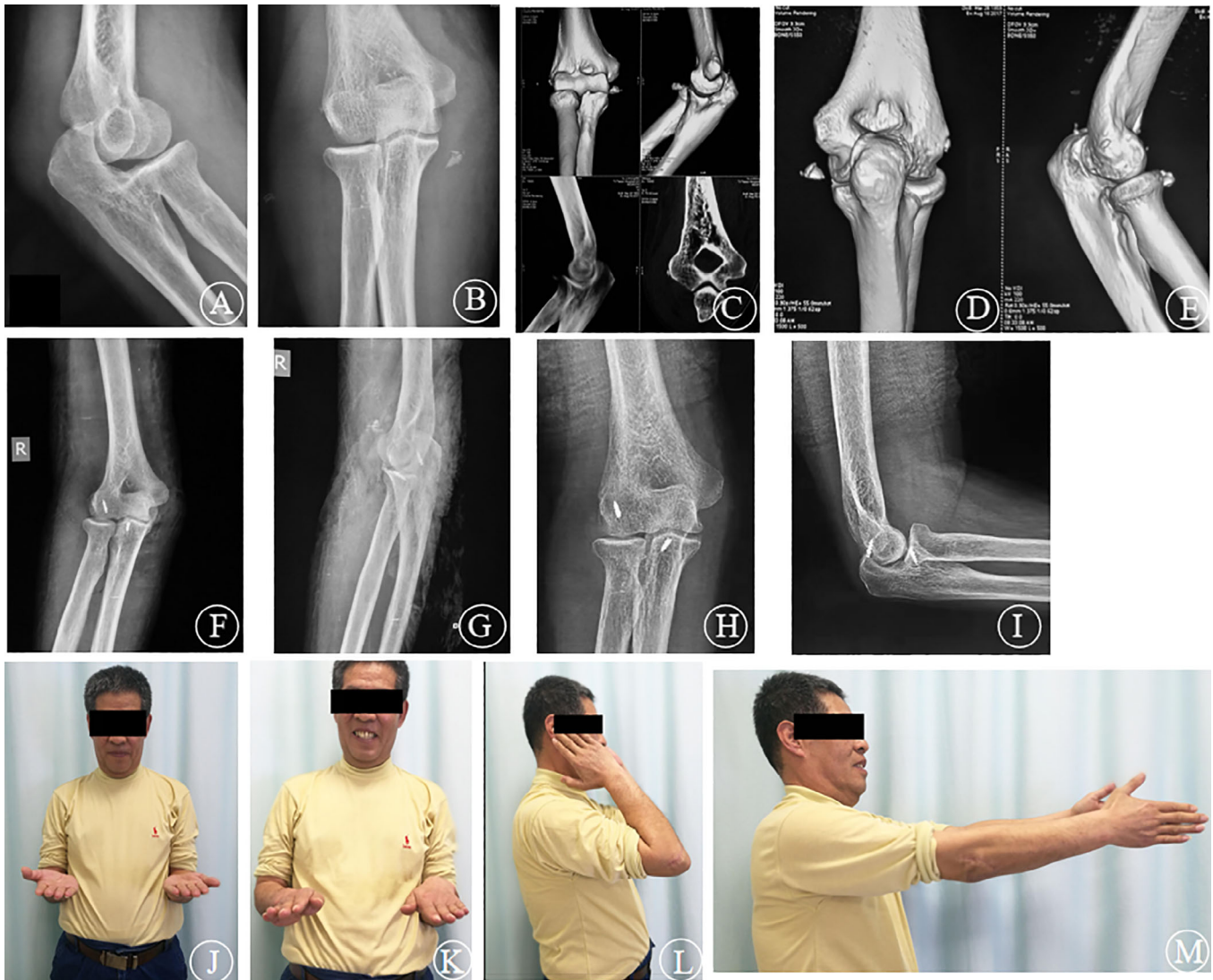


Fig 3 A 52-year-old male who had a right elbow varus posteromedial rotatory instability (PMRI) due to a traffic accident. (A) The preoperative lateral X-ray demonstrated subluxation of elbow joint. (B) The preoperative antero-posterior X-ray showed anteromedial facet coronoid fractures and humeral lateral epicondylar avulsion fractures. (C, D, E) The anteromedial facet coronoid fracture and humeral lateral epicondylar avulsion fractures were shown on computed tomography (CT) and 3D reconstruction. (F) The coronoid fractures and humeral lateral epicondylar avulsion fractures were treated with suture anchor fixation and the intraoperative antero-posterior X-ray showing equal space between the medial and lateral joint space. (G) The intraoperative lateral X-ray was taken in the extension-supination position and showed no subluxation or dislocation in the elbow joint. (H, I) The antero-posterior and lateral X-ray of the elbow at postoperative 24 months. (J, K) The appearance of the elbow pronation and supination at postoperative 24 months. (L, M) The appearance of the elbow flexion and extension at postoperative 24 months.

to 1.88 ± 0.781), and no significant differences in preoperative or final follow-up were observed between the two groups ($P = 0.487$, $P = 0.876$). The clinical score results are presented in Table 3.

Postoperative Complications

Regarding postoperative complications, none of these result observed superficial wound infections, nonunion, delayed union, arthritis, and chronic instability. There was no statistically significant differences in postoperative complications

between the two groups. But one patient in group NL had cubital tunnel syndrome at 3 months after the operation. Doppler ultrasonic examination showed ulnar nerve entrapment. The patient underwent ulnar nerve simple neurolysis and the symptoms were relieved after 3 weeks.

Discussion

There are three patterns of complex elbow instability: Terrible triad, PMRI, and trans-olecranon fracture dislocation¹⁰. Multiple causes of injury can result in complex

TABLE 3 Clinical score results

Variables	Group RL(n = 15)	Group NL(n = 9)	P-value
MEPS score	90.53 ± 2.695	89.77 ± 3.865	0.578 ^{&}
Excellent	13(87%)	8(89%)	0.873 [*]
Good	2(13%)	1(11%)	0.873 [*]
Fair	0	0	
Poor	0	0	
VAS score			
Preoperative	6.13 ± 0.990	5.77 ± 1.481	0.487 ^{&}
Final follow-up	1.93 ± 0.593	1.88 ± 0.781	0.876 ^{&}
DASH score	9.77 ± 1.897	9.99 ± 1.550	0.772 ^{&}

DASH, Disabilities of the arm, shoulder, and hand score; Group RL(repair LUCL); Group NL(non-repair LUCL); MEPS, Mayo elbow performance score; VAS, Visual Analog Scale; [&]Independent t-test. ^{*}Fisher's exact test or chi-square test; The P-value shown is for inter-group comparison.

elbow instability. Persistent elbow instability after injury often leads to pain, dysfunction, and progressive joint degeneration. Therefore, surgeons need to restore the anatomical structure of the elbow joint so as to facilitate prompt functional exercise after repair. It is challenging for the surgeon to determine which structures to repair. Fixing all of the injured structures may increase the difficulty of the operation and the incidence of adverse complications, but fixing too few injured structures can lead to the patient's functional activity being poor¹⁹.

The main injury mechanism of PMRI is that the elbow joint receives varus and posteromedial rotation stress under axial load. When the shoulder joint is stretched forward, the upper limb is vertical, and the hand is supported by axial stress, which causes the elbow joint to pronate and the forearm to rotate in the backward and medial directions²⁰. The varus stress on the inside leads to the coronoid fracture involvement of the anteromedial rim and sublime tubercle, and the tensile stress on the outside leads to complex injury of the LCL^{21,22}. Few patients present with frank dislocation can bring the arm stretches out 90° for elbow flexion-extension and these patients will be feeling pain, grinding, or instability during physical examination²³. Pollock *et al.* confirmed that the gravity-assisted varus stress test is the most sensitive in preoperative physical examinations, but false-negatives sometimes occur²⁴. Computed tomography (CT) scans that are 3-dimensional (3D) are recommended for the majority of patients with these injuries because X-rays may only show the anteromedial aspect of the coronoid fracture, and sometimes the bony fragmentation of the lateral epicondyle of LCL avulsion cannot easily be found.

Based on previous studies, the consensus for conservative treatment of coronoid fracture was that the coronoid process fragment is <5 mm and not easy to fix; otherwise, internal fixation is required²⁵. But repairing the MCL and LCL are controversial in the treatment of PMRI. The MCL mainly provides 54% stability of the elbow in flexion, as the anterior bundle and posterior bundle of the MCL (as the

primary stable structures) resist valgus instability^{23,26}. Biomechanical studies have shown that elbow gross subluxation occurs when the posterior bundle of the MCL has to be disrupted in the presence of an anteromedial fracture and disruption of the LCL²⁷. However, Carlo *et al.* found that there were no significant differences between surgical and conservative treatment of MCL in terms of the functional outcomes, but the conservative treatment had a higher complication rate and lower patient satisfaction²⁸. Hwang *et al.* concluded that repairing the broken MCL is associated with increased flexor pronator group disruption, and the risk of ulnar nerve injury, arthritis, and infection²¹. Furthermore, Shukla *et al.* suggested that MCL repair should be used only if instability persists after management of the coronoid, LCL, and radial head for complex elbow instability²⁹. This conclusion is consistent with our ideas. We also found that the MCL has potential for spontaneous healing. For patients with anteromedial facet fractures of the coronoid and displacement of the anterior bundle of the MCL, only the coronoid fracture needs to be fixed during the operation.

The LCL complex is formed by the LUCL, radial collateral ligament, annular ligament, and accessory lateral collateral ligament. This complex is considered to be the primary stabilizer of the elbow, but rupture of the LCL does not directly cause PMRI. It is utilized to resist varus stress (approximately 10% varus stress) and prevent subluxation^{26,27}. The LUCL injury was shown as an avulsion fracture or ligament at the insertion of the humerus. Anatomical studies demonstrate that the LUCL is relaxed in the extension-supination position, and the radial collateral ligament pulls the annular ligament upward of tension LUCL during flexion. An elbow joint with an LCL defect is the most unstable in supination. Furthermore, Morrey *et al.* showed that the anterior capsule and the joint articulation contribute 32% and 55% to resist varus stress at 90° elbow flexion, and the anterior capsule provides 85% of the resistance to distraction while in extension. The maximum elbow instability of the position is 70° flexion and neutral rotation^{30,31}.

Taking into account these study results, we try to treat PMRI without repairing the LUCL. We do not perform a varus stress test, but we do take an X-ray in the extension-supination position of the elbow joint after reconstructing the coronoid fracture. If the X-ray shows no dislocation or subluxation, the LUCL does not need to be repaired; otherwise, the LUCL needs to be reconstructed. Our study analyzed the results of 24 patients with elbow PMRI who received internal fixation of the coronoid fracture and repair of the LUCL (group RL) or only internal fixation of the coronoid fracture (group NL). For pain relieving and elbow function recovery, VAS, MEPS, and DASH achieved satisfactory results after surgery in both groups. Owing to the fact that the LUCL was not repaired in group NL, the mean duration of surgery and blood loss were significantly lower compared to that in group RL. Bone nonunion, delayed union, and post-traumatic arthritis changes were not reported during the follow-up. So, some patients who

suffered PMRI could achieve satisfactory pain relief and functional results with reconstruction of the coronoid fracture and no treatment of the LUCL.

For patients in group NL, we found that the coronoid fragment was smaller than in group RL. We speculate that the functional integrity of the coronoid process is the key factor for determining whether the LUCL needs to be repaired. The larger coronoid process fragment associated with high-energy trauma and the LUCL need more active repair. After reconstruction of the coronoid fracture, the primary stabilizer enables the elbow to obtain axial and rotational “relative stability” (not really stable) in the extension-supination position. In our opinion, the purpose of reconstructing the coronoid fracture with suture anchors, cannulated screws, or a plate is to obtain relative stability of the anterior column to create the conditions for self-healing of the LUCL. But the different functional outcomes of the three kinds of internal fixation instruments were not considered in our study, and we need more samples and prospective comparative studies to investigate any differences.

The present study includes several limitations. First, the sample size was relatively limited. Second, the patients were not randomized into different groups in this retrospective study. Third, there were multiple internal fixation instruments and techniques used to reconstruct the coronoid fracture and LUCL, which may introduce significant

variability and reduce the validity of the study. However, both groups had similar baseline data, and most patients obtained satisfactory results in our study. This study is the first to compare repair of the LUCL in the clinical treatment of PMRI. Our intraoperative evaluation method could provide reference for the management of PMRI.

Conclusion

This study demonstrates that satisfactory functional outcomes can be achieved with non-repair of the LUCL in the surgical treatment of PMRI. Excluding repair of the LUCL also lowers the mean duration of surgery and reduces blood loss. However, if an X-ray of the elbow joint in the extension-supination position shows subluxations or dislocations after fixation of the coronoid fractures, the LUCL needs to be reconstructed.

Acknowledgments

The authors acknowledge Dr Desheng Zhao for the assistance in figure drawings.

Authorship Declaration

All authors acknowledge that they meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and that all authors are in agreement with the manuscript.

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