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Functional outcomes after treatments for different types of isolated ulnar coronoid fracture

A protocol for systematic review

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Abstract

Background: Optimal treatments for ulnar coronoid fracture have yet to be determined. We aimed to systematically review treatment efficacy assessed by functional outcomes of patients with isolated ulnar coronoid fracture.

Methods: Medline, Cochrane Library, EMBASE, and Google Scholar were searched for studies reporting quantitative outcomes data after surgical treatment for isolated ulnar coronoid fractures up to July 16, 2019. Functional outcomes determined using disabilities of the arm, shoulder and hand score; Mayo elbow performance score (MEPS); and range of motion were systematically reviewed.

Results: Six studies with a total of 65 patients with isolated coronoid fracture who had received surgical treatment were included. All studies were of good quality according to a modified Delphi checklist. Most patients had Type II fractures based on Regan-Morrey or O'Driscoll classification. Disabilities of the arm, shoulder and hand scores were reported by 2 studies (mean range 5–17). Four studies reported MEPS (mean range 89–98). One study reported Broberg-Morrey scores, in which 93% patients achieved excellent or good outcomes. Five studies reported range of motion, with mean flexion ranging from 122 to 137 and mean extension ranging from 4.0 to 21 degrees. Quantitative analyses revealed that lateral, medial, or posterior approaches in treating Type II fractures are associated with higher postoperative MEPS and flexion scores than the anteromedial approach.

Conclusions: Treatment efficacy assessed by functional outcomes for isolated ulnar coronoid fractures is overall satisfactory. Whether lateral, medial, or posterior approaches lead to more favorable outcomes than the anteromedial approach is inconclusive. Further prospective studies are warranted.

Abbreviations: CI = confidence interval, DASH = disabilities of the arm, shoulder, and hand, LMP = lateral, medial, or posterior, MEPS = Mayo Elbow Performance Score, PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses, QA = quality assessment, ROM = range of motion.

Keywords: coronoid fracture, coronoid process fracture, treatment, ulnar coronoid fracture

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1. Introduction

The coronoid process is the key osseous stabilizer of the elbow joint.[1] Fractures of the coronoid process are thought to occur due to axial loading of the elbow, and are often associated with elbow dislocation.[2,3] Fractures of the coronoid process are rare, and are associated with concomitant injuries in 2% to 11% of elbow luxations.[4,5] About 58% of the anteromedial coronoid is unsupported by the proximal ulnar metaphysis and diaphysis, and is particularly prone to injury.[6] Fracture type is related to the mechanism of injury, and also may impact the choice of treatment.[7,8]

A number of classification methods are used to describe coronoid fractures. Based on involvement of the coronoid process, Regan and Morrey introduced 3 classes: Type I fractures involving the tip of the coronoid, Type II fractures involving more than the tip and <50% of the coronoid, and Type III fractures involving >50% of the coronoid.[9] The O'Driscoll classification system subdivides coronoid injuries based on the location and number of coronoid fragments[10]: Type I is a tip fracture, Type II is an anteromedial facet fracture, and Type III is a fracture through the base of the process.[10] Several scoring systems grade clinical fracture severity of the elbow and functional outcomes, including disabilities of the arm, shoulder and hand (DASH) Score,[11,12] Mayo Elbow Performance Score (MEPS),[13,14] and the Broberg-Morrey rating system.[15]

From 23% to 61% of coronoid fractures are treated surgically.[9,16] Although management of coronoid fractures is complex, several surgical interventions addressing different fracture patterns are considered effective treatment options, and current recommendations are to repair all coronoid fractures with elbow instability.[17,18] Stable fixation and ligament repair are considered essential.[19] The surgical approach varies depending on fracture severity and the presence of concomitant injuries (e.g., radial head injury).[18] A lateral approach is usually performed when an associated radial head fracture is present. A medial approach is used for an isolated coronoid fracture. Repairing large coronoid fractures can be challenging. Suture anchors are used for repairing small coronoid process fractures by suturing the bone and anterior capsule to the anterior ulna.[17] Small coronoid fractures can also be treated with elbow immobilization only.[18] Small coronoid fractures with radial head fractures, or with posteromedial instability, can be stabilized by "lasso-type" sutures or suture anchors that incorporate the capsular attachment of the fragment. Larger fragments may require screws, and large anteromedial facet fractures may require plates.[18] Complex Monteggia fractures and trans-olecranon fracture dislocations with bone and soft tissue involvement can only be treated with plates and screws.[18] Arthroscopic-assisted techniques provide open reduction and external fixation.[18] After coronoid stabilization, other components of each specific injury pattern must be treated (e.g., radial head fracture).[18]

Although a range of methods are available to manage coronoid process fractures, their effectiveness has not been systematically reviewed to date. Also, optimal treatments according to different coronoid fracture types remain to be determined. We hypothesized that assessing treatments by functional outcomes may reveal important differences between surgical approaches for different types of ulnar coronoid fractures. Given this context, we conducted a systematic review of the literature, aiming to compare the clinical efficacy of treatments for ulnar coronoid fractures and evaluating differences between surgical approaches.

2. Material and methods

2.1. Search strategy

Medline, Cochrane, EMBASE, and Google Scholar databases were searched from inception to July 16, 2019. The Medline search was performed using the term "ulnar coronoid fractures." and Cochrane and EMBASE searches with the term "coronoid fracture." The availability of the abstract and the publication language (English) were used as filters in Medline and EMBASE searches.

This study was performed in accordance with the "participants, intervention, comparison, outcomes, study design" criteria. Published clinical studies in English (S) were considered for inclusion in the review; the included clinical studies must report follow-up of patients who had ulnar coronoid fractures (*P*) and received surgical or non-surgical treatment with or without a control group (I and C); the included clinical studies must report functional outcomes (O) after treatment. Studies focused on complex elbow injuries were excluded. Letters, commentaries, editorials, proceedings, and personal communications were also excluded. The reference lists of included studies were hand-searched to identify other potentially relevant studies.

For this review, the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) checklist was complete, and a PRISMA 2009 flow diagram was produced to demonstrate the process of study selection.[20]

2.2. Study selection and data extraction

Data were extracted by 2 independent reviewers who consulted with a third reviewer to resolve any uncertainties and discrepancies of eligibility. The following information/data were extracted from studies that met the inclusion criteria: the name of the first author, year of publication, study design, number, sex, and age of patients, Regan-Morrey classification for coronoid fractures, O'Driscoll classification system for coronoid injuries, mechanism of injury, time from injury to surgery, treatment approaches for ulnar coronoid fractures, and functional outcomes (measured by DASH score; MEPS, Broberg-Morrey score, and range of motion [ROM]). Ethical approval for a systematic investigation (gathering published information) was not required.

2.3. Quality assessment

The quality of the included studies was assessed by the modified 18-item Delphi checklist.[21] Quality assessment (QA) score was obtained by counting how many items the included study met. The maximum QA score was 18.

2.4. Main outcome measures

The primary outcome of the present review is treatment efficacy, which was assessed by patients' functional outcomes as measured by DASH scores, MEPS, Broberg-Morrey scores, and ROM.

2.5. Statistical analysis

The efficacy of surgical approaches was evaluated based on post-treatment functional outcomes measured by DASH, MEPS, flexion, extension, pronation and supination. All effect sizes were summarized or calculated using mean, variance, and 95% confidence intervals (CIs) for each group and subgroup. Pooled effects were calculated as mean with variance and 95%CIs for overall analysis and for subgroup analysis. A 2-tailed P value $< .05$ was established as statistical significance.

3. Results

3.1. Search results

A total of 169 potential studies were identified in the initial literature search (Fig. 1). Of these, 139 were excluded for not being relevant after reviewing titles and abstracts. Thirty studies underwent full-text review, and 24 were excluded for not investigating surgical treatments, not reporting quantitative outcomes, or investigating coronoid fractures involving complex elbow injuries or terrible triad injuries. Finally, 6 studies were included in the systematic review.

3.2. Study characteristics

The main characteristics of the 6 included studies[5,22–26] are summarized in Table 1. The number of patients in the studies ranged from 5 to 18 (total = 65). The patients' ages ranged from 14.9 to 39.4 years. More than 61% of the patients were male. The

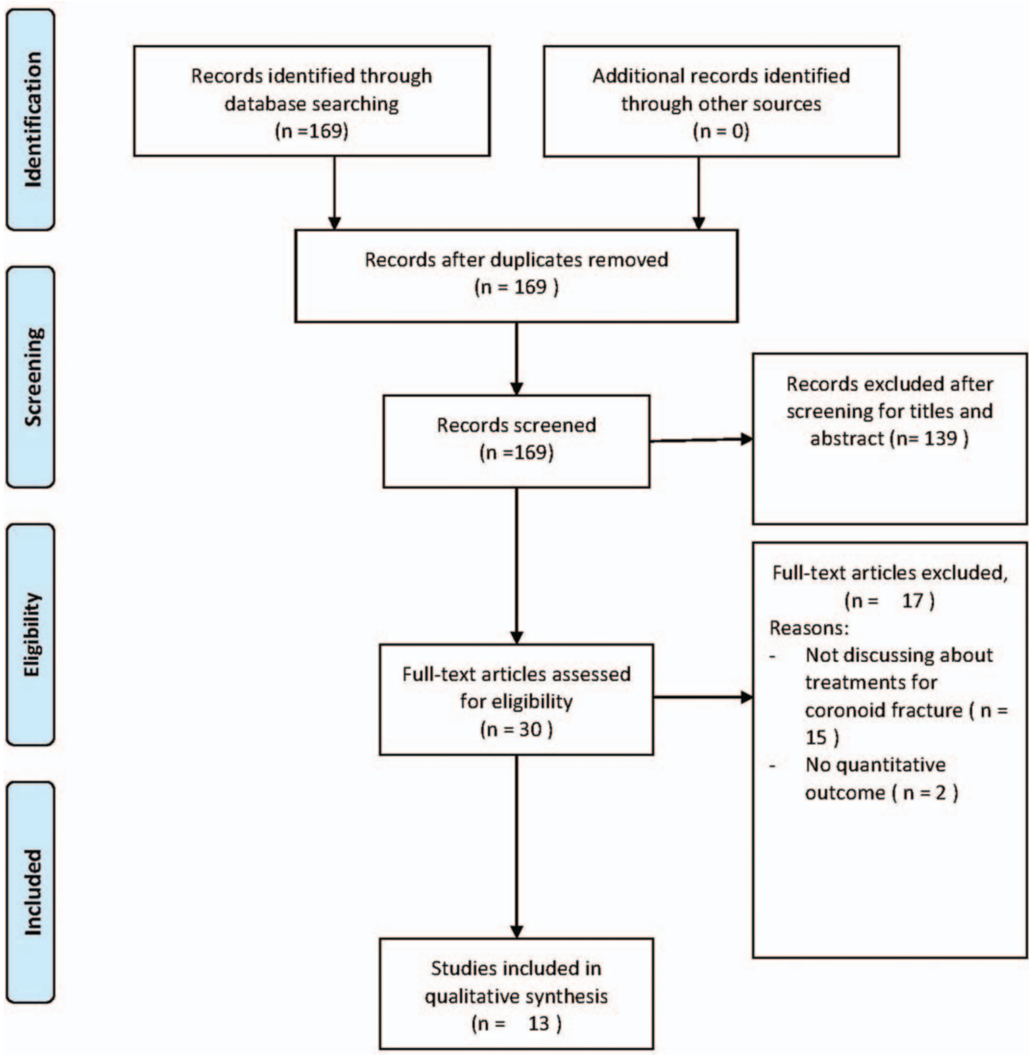

Figure 1. PRISMA 2009 flow diagram of study selection.

length of follow-up ranged from 9.3 to 68.4 months. Most patients had Type II fractures (a fragment involving ≤50% of the process by the Regan-Morrey classification) as classified by either the Regan-Morrey or O'Driscoll classification systems. Treatment approaches and the causes of injuries varied across studies (Table 1).

3.3. Surgical management and functional outcomes

Adams et al (2007)[26] retrospectively reviewed the outcomes of 7 patients with coronoid fractures who were treated arthroscopically (Table 1). Four fractures were Type II and 3 were Type III by Regan-Morrey classification. Fracture fixation included plate and screws after arthroscopic reduction (n=1), screws (n=2), threaded Steinmann pins (n=2). In 2 cases, only fracture debridement was performed. All patients reported good function and no pain after an average follow-up of 31.8 months. ROM averages were: 9° for flexion, 133°for extension, 87° for pronation, and 79° for supination. MEPS was 100 (excellent) in 5 patients (Table 2).

In the other 5 studies,[5,22–25] open reduction and internal fixation was used with an anteromedial,[23,25] or lateral, medial, or posterior (LMP)[5,22,24] approach. Fixation and ligament repair were used depending upon the severity of the fracture (Table 1). Fractures were Types I, II, and III, based on the O'Driscoll classification. Across the studies, treatments resulted in stabilization and good clinical outcomes. For ROM, flexion ranged from 122° to 134°, extension from 4° to 21°, pronation from 67° to 86°, supination from 61° to 89°, flexion/extension arc from 102° to 125°, and pronation/supination arc from 128° to 173°. DASH scores ranged from 5 to 17, and MEPS ranged from 89 to 98. The Broberg-Morrey score (only performed in 1 study) was 92.5, with 93% of patients achieving excellent/good outcomes.

3.4. Comparison of functional outcomes by surgical approach and fracture types

The results of quantitative analyses revealed that MEPSs were significantly influenced by the anteromedial approach (pooled mean MEPS=95.5; 95%CI: 93.4 to 97.6, $P<.001$) and the LMP

Table 1

Characteristics of studies included in the systematic review.

First author (yr)	Classification (%)	Number of patients	Age (yr)	Male (%)	Follow-up (mo)	Time from injury to surgery (d)	QA
Isolated ulnar coronoid process fracture							
Chan K (2016)	O'Driscoll, II: 90%; III: 10%	10	49	60.00%	50	NR	14
Chen H (2015)	O'Driscoll, I: 33%; II: 56%; III: 11%	18	14.9	61.10%	33.6	3.9	10
Mallard F (2015)	Regan-Morrey, IIa: 20%; IIb: 60%; IIIb: 20%	5	39.3	80.00%	68.4	NR	10
Park SM (2015)	O'Driscoll, type II-1: 18%; type II-2: 36%; type II-3: 45%	11	42	63.60%	31	NR	15
Rhyou IH (2014)	O'Driscoll, II:100%	18	39.4	88.90%	37	NR	13
Zhang C (2013)	O'Driscoll, II b and II c:100%	6	32.6	66.70%	9.3	6.8	10
Adams JE (2007)	Regan-Morrey, II: 57%; III: 43%	7	37	NR	31.8	8	9
With terrible triad							
Papatheordorou, LK. (2014)	Regan-Morrey, I: 14%; II: 86%	14	52	42.80%	41	3	12
Garrigues GE (2011)	Regan-Morrey, I: 7%; II: 93%	28	48	55.00%	24	NR	15
	Regan-Morrey, II: 86%; III: 14%	7					
	Regan-Morrey, II: 80%; III: 20%	5					

First author (yr)	Coronoid treatment				Classification (%)	Concomitant injury	Mechanism of injury (%)
Isolated ulnar coronoid process fracture	Surgical method	Exposure approach	Fixation	Ligament repair			
Chan K (2016)	Non-operative				O'Driscoll, II: 90%; III: 10%	No	Fall from height: 50%; fall from a ladder:10%; sports-related: 40%.
Chen H (2015)	ORIF	anteromedial	Mini-plate; Screw & rivet; Plate & screw assisted fixation	LCL	O'Driscoll, I: 33%; II: 56%; III: 11%	No	Fall on the ground: 83%; traffic injuries: 17%
Mallard F (2015)	ORIF	lateral (3/5), medial (1/5) or posterior (1/5)	Internal fixation by tension band wiring with steel wire	NA	Regan-Morrey, IIa: 20%; IIb: 60%; IIIb: 20%	No	NR
Park SM (2015)	ORIF	lateral, medial or posterior	buttress plating	subtype 1, LCL (Bio-SutureTak anchor); subtypes 2 and 3, buttress plating and LCL repair.	O'Driscoll, type II-1: 18%; type II-2: 36%; type II-3: 45%	No	Slip down: 45%; fall down: 27%; motorcycle: 18%; sports: 9%
Rhyou IH (2014)	ORIF	lateral or medial	cannulated screw, K-wire with tension band, and Mayo buttress plate	$<$5 mm, LUCL (suture anchor); $>$5 mm, LUCL, MCL (suture anchor)	O'Driscoll, II:100%	No	Slip: 17%; fall from a height: 39%; traffic acci- dent: 33%; sporting acci- dent: 11%
Zhang C (2013)	ORIF	anteromedial approach	screw	NA	O'Driscoll, II b and II c:100%	No	Fall while walking: 33%; being hitted: 17%; bicycle accident: 33%; motorcycle accident: 17%;
Adams JE (2007)	arthroscopic reduction and internal fixation		plate-and-screws; screw, threaded Steinmann pin	LUCL	Regan-Morrey, II: 57%; III: 43%	No	Fall from a height: 29%; fall on the ground: 57%; motocross-related injury: 14%
With terrible triad							
Papatheordorou, LK. (2014)	Non-operative		NR	LUCL (suture anchors)	Regan-Morrey, I: 14%; II: 86%	Terrible triad	Fall from a height: 86%; motor vehicle acci- dents:14%
Garrigues GE (2011)	Lasso technique	Posterior, lateral or medial	Suture Lasso Treatment	LUCL (suture anchors)	Regan-Morrey, I: 7%; II: 93%	Terrible triad	NR
	ORIF		Suture Anchor Treatment		Regan-Morrey, II: 86%; III: 14%		
			Screw Treatment		Regan-Morrey, II: 80%; III: 20%		

LCL = lateral collateral ligament, LUCL = lateral ulnar collateral ligament, MCL = medial collateral ligament, NR = not reported, ORIF = open reduction and internal fixation, QA = quality assessment by a modified 18-items Delphi technique.

Table 2

Functional outcomes of included studies.

First author (yr)	Surgical method	Exposure method	O'Driscoll type of coronoid fracture	Number of patients	DASH Score	MEPS Score	MEPS Excellent (n)	MEPS Good (n)	Broberg-Morrey Score	Broberg-Morrey Excellent (n)	Broberg-Morrey Good (n)	Flexion	Extension	Flexion/extension arc	Pronation	Supination	Pronation/supination arc
Isolated ulnar coronoid process fracture																	
Chan K (2016)	Non-operative	NR	II+III	10	7±9	94±8	6	4	NR	NR		137	2	135	88	86	174
Chen H (2015)	ORIF	Anteromedial approach	Total	18	NR	95.5 (82–100)*	12	5	92.5	9	7	122	20	102	67	61	128
			I	6		97±4.1	5	1	95.5±4.46	4	2						
			II	10		93±8.78	6	3	90.9±8.33	5	3						
			III	2		93.5±6.36	1	1	91.5±2.12	0	2						
Mallard F (2015)	ORIF	Lateral, medial or posterior approach	Regan-Morrey:IIa+IIb+IIIb	5	17.05±8.93	91.0±4.0	3	2	NR	NR	NR	137.0°±2.0°	21.0°±7.81°	115.0°±9.62°	86.0°±1.87°	85.0°±4.47°	171
			II	4	21.3±8.93	88.75±8.54						136.25±4.78°	26.25±14.93°		85.0±4.1°	82.5±9.57°	
Park SM (2015)	ORIF	Lateral, medial or posterior approach	I+II+III	11	NR	89±11	4	6	NR	NR	NR	134±8	6±7	128±12	NR	NR	NR
			I	2		100±0	2	0									
			II	4		80±10	0	3									
			III	5		91±8.22	2	3									
Rhyou IH (2014)	ORIF	Lateral, medial or posterior approach	II	18	5.6(0–35.8)*	98 (85–100)*	16	2	NR	NR	NR	NR	NR	NR	NR	NR	NR
Zhang C (2013)	ORIF	Anteromedial approach	IIb, IIc	6	NR	NR	NR	NR	NR	NR	NR	129.0±6.5	4.0±4.2	125	84.0±6.5	89.0±7.1	173
Adams JE (2007)	arthroscopic reduction and internal fixation	NR	Regan-Morrey: II, III	7	NR	NR	NR	NR	NR	NR	NR	133 (120–145)*	9 (0–30)*	124	87 (85–90)*	79 (45–90)*	166
With terrible triad																	
Papatheordorou, LK (2014)	Non-operative	NR	Regan-Morrey: I, II	14	14 (0–38)*	NR	NR	NR	90	5	8	134 (95–140)*	11 (0–20)*	123 (75–140)*	82 (50–90)*	64 (20–80)*	145 (70–170)*
Garrigues GE (2011)	Lasso technique	NR	Regan-Morrey: I, II	Suture Lasso Treatment n=28	16	NR	NR	NR	90	NR	NR	136	18	118	NR	NR	NR
	ORIF			Suture Anchor Treatment n=7	Anchor: 19	NR	NR	NR				133	30	103	NR	NR	NR
				Screw Treatment n=5	Screw: 11	NR	NR	NR				138	22	116	NR	NR	NR

MEPS scores: excellent ≥ 90, good 75–89.
Broberg-Morrey score: excellent 95–100, good 80–94.
NR=no response, ORIF=open reduction and internal fixation.
* range (min.-max.).

Table 3

Functional outcomes of patients with isolated coronoid fractures by surgical approach.

Outcomes	Surgical approach	Number of studies*	Pooled value					
			Mean	Variance	Lower limit	Upper limit	Z-value	*P*-value
DASH	Lateral, medial or posterior approach	2	10.823	32.523	−0.355	22.000	1.898	.058
MEPS	Anteromedial approach	1	95.500	1.125	93.421	97.579	90.038	<.001
	Lateral, medial or posterior approach	3	93.138	9.344	87.146	99.129	30.469	<.001
Flexion	Anteromedial approach	1	129.000	2.347	125.997	132.003	84.200	<.001
	Lateral, medial or posterior approach	2	136.336	1.550	133.896	138.777	109.490	<.001
Extension	Anteromedial approach	1	4.000	0.980	2.060	5.940	4.041	<.001
	Lateral, medial or posterior approach	2	13.242	56.183	−1.449	27.933	1.767	.077
Pronation	Anteromedial approach	1	84.000	2.347	80.997	87.003	54.828	<.001
	Lateral, medial or posterior approach	1	86.000	0.699	84.361	87.639	102.835	<.001
Supination	Anteromedial approach	1	89.000	2.801	85.720	92.280	53.182	<.001
	Lateral, medial or posterior approach	1	85.000	3.996	81.082	88.918	42.520	<.001

Note: Aggregated statistics were calculated using individual patient data for Chen H (2015), Mallard F (2015), Park SM (2015), Rhyou IH (2014), and Zhang C (2013).
DASH= disabilities of the arm, shoulder, and hand, MEPS = Mayo elbow performance score.

approach (pooled mean MEPS=93.1; 95%CI: 87.1 to 99.1, $P<.001$) (Table 3). Flexion, pronation, and supination were also significantly affected by both approaches (all, $P<.05$). However, DASH and extension were not affected by the LMP approach (pooled mean DASH=10.8, 95%CI: −0.36 to 22.0; extension= 13.2, 95%CI: −1.4 to 27.9; both, $P>.05$) (Table 3).

As shown in Table 4, the MEPS scores were also significantly affected by fracture type. Pooled mean MEPS was 97 (95%CI: 93.7 to 100.3) for patients with Type I fractures, 91.1 (95%CI: 84.2 to 98.0) for those with Type II fractures, and 92 (95%CI: 86.4 to 97.6) for patients with Type III fractures. For patients with Type II fractures alone, the pooled mean DASH was 10.5 (95%CI: –3.1 to 24.0), flexion 132.7 (95%CI: 125.6 to 139.8), extension 13.9 (95%CI: –7.7 to 35.6), pronation 84.6 (95%CI: 81.5 to 87.8), and supination 86.9 (95%CI: 80.9 to 92.8).

When stratified by MEPS for different approaches, patients with Type II fractures who received the LMP approach had a higher MEPS than those receiving the anteromedial approach (mean MEPS=96.6; 95%CI: 94.5 to 98.7 vs 93.0; 95%CI: 87.6 to 98.4) (Table 5). Patients who received the LMP approach also had better flexion and extension than did those receiving the anteromedial approach (pooled mean flexion=136.2; 95%CI: 131.5 to 140.9 vs 129; 95%CI: 123.8 to 134.2; pooled mean extension=26.25 (95%CI: 11.6 to 40.9 vs 4; 95%CI: 0.6 to 7.4) (Table 5).

3.5. Quality assessment

Results of the 18-item Delphi quality assessment are shown in Table 6. Studies with QA scores ranging from 9 to 15 were classified as good quality. QA results indicated that the articles selected for this system review were of good quality.

4. Discussion

We systematically reviewed the functional outcomes of patients who underwent surgical treatments for isolated ulnar coronoid fracture, and compared these outcome scores between specific surgical approaches. The results suggest that the current surgical treatments provide satisfactory functional outcomes as measured by DASH scores and MEPS. In addition, results of quantitative analyses showed that in patients with Type II coronoid fracture alone, those who received the LMP approach had higher MEPS and flexion scores than did those receiving the anteromedial approach.

Prior reviews have summarized treatments and prognoses for coronoid fractures, with most indicating that treatment is determined based on fracture characteristics.[18,27–29] However, precisely how to handle small fractures is controversial. Two reviews suggested that surgery may not be needed for small coronoid fractures, particularly those that do not involve capsular attachments; instead authors suggest that they should

Table 4

Functional outcomes of patients with isolated coronoid fractures by fracture type.

Outcomes	Subgroup	Number of studies	Pooled statistics					
			Mean	Variance	Lower limit	Upper limit	Z-value	*P*-value
DASH	Type of fracture: II	2	10.465	47.916	−3.102	24.032	1.512	.131
MEPS	Type of fracture: I	1	97	2.8	93.72	100.28	57.965	<.001
	Type of fracture: II	4	91.094	12.479	84.171	98.018	25.787	<.001
	Type of fracture: III	2	92	8.1	86.422	97.578	32.325	<.001
Flexion	Type of fracture: II	2	132.716	13.132	125.613	139.818	36.623	<.001
Extension	Type of fracture: II	2	13.939	122.359	−7.742	35.619	1.260	.208
Pronation	Type of fracture: II	2	84.628	2.617	81.457	87.799	52.31	<.001
Supination	Type of fracture: II	2	86.866	9.316	80.884	92.849	28.46	<.001

Note: Aggregated statistics were calculated using individual patient data for Chen H (2015), Mallard F (2015), Park SM (2015), Rhyou IH (2014), and Zhang C (2013).
DASH= disabilities of the arm, shoulder, and hand, MEPS = Mayo elbow performance score.

be treated only with immobilization.[28,29] In contrast, other studies have suggested that all fractures, regardless of size, should

Table 5

Functional outcomes of patients with isolated coronoid fracture by fracture type and surgical approach.

		Anteromedial approach							Lateral, medial, or posterior approach						
Outcome	Fracture type	Number of studies	Mean	Variance	Lower limit	Upper limit	Z-value	*P*-value	Number of studies	Mean	Variance	Lower limit	Upper limit	Z-value	*P*-value
MEPS	Type I	1	97.00	2.80	93.72	100.28	57.97	.001	-	-	-	-	-	-	-
	Type II	1	93.00	7.71	87.56	98.44	33.49	<.001	3	96.60	1.18	94.47	98.73	88.89	<.001
	Type III	1	93.50	20.25	84.68	102.32	20.78	<.001	1	91.00	13.50	83.80	98.20	24.77	<.001
Flexion	Type II	1	129.00	7.04	123.80	134.20	48.61	<.001	1	136.25	5.73	131.56	140.94	56.93	<.001
Extension	Type II	1	4.00	2.94	0.64	7.36	2.33	.02	1	26.25	55.73	11.62	40.88	3.52	<.001
Pronation	Type II	1	84.00	7.04	78.80	89.20	31.66	<.001	1	85.00	4.17	81.00	89.00	41.65	<.001
Supination	Type II	1	89.00	8.40	83.32	94.68	30.71	<.001	1	82.50	22.92	73.12	91.88	17.23	<.001

Note: Aggregated statistics were calculated by using individual patient data for Chen H (2015), Mallard F (2015), Park SM (2015), Rhyou IH (2014), and Zhang C (2013).
MEPS = Mayo elbow performance score.

Table 6

Quality assessment of included studies with modified 18-item Delphi technique.

	Isolated ulnar coronoid process fracture							With Terrible Triad	
Checklist	Chan K (2016)	Chen H (2015)	Mallard F (2015)	Park SM (2015)	Rhyou IH (2014)	Zhang C (2013)	Adams JE (2007)	Loukia K (2014)	Garrigues GE (2011)
Is the hypothesis/aim/objective of the study clearly stated in the abstract, introduction, or methods section?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are the characteristics of the participants included in the study described?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were the cases collected in more than one centre?	N	N	N	N	N	N	N	N	Y
Are the eligibility criteria (inclusion and exclusion criteria) to entry the study explicit and appropriate?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were participants recruited consecutively?	N	N	N	Y	N	N	N	Y	Y
Did participants enter the study at a similar point in the disease?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the intervention clearly described in the study?	Y	N	Y	Y	Y	Y	Y	Y	Y
Were additional interventions (co-interventions) clearly reported in the study?	NA	NA	NA	NA	NA	NA	NA	NA	NA
Are the outcome measures clearly defined in the introduction or methods section?	Y	N	N	Y	Y	N	N	Y	Y
Were relevant outcomes appropriately measured with objective and/or subjective methods?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were outcomes measured before and after intervention?	N	N	N	N	N	N	N	N	N
Were the statistical tests used to assess the relevant outcomes appropriate?	Y	NA	NA	Y	Y	NA	NA	NA	Y
Was the length of follow-up reported?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the loss to follow-up reported?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Does the study provide estimates of the random variability in the data analysis of relevant outcomes?	Y	NA	NA	Y	Y	NA	NA	NA	Y
Are adverse events reported?	Y	Y	Y	Y	N	Y	N	N	N
Are the conclusions of the study supported by results?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are both competing interest and source of support for the study reported?	Y	Y	Y	Y	Y	N	N	Y	Y

Y = low risk of bias, N = high risk of bias, NA = unclear risk of bias.

be surgically treated when instability exists, and even small or comminuted fractures should be treated with suture fixation.[17,27,29] Beingessner et al[30] even suggested that suture repair of the coronoid did not correct instability and that suture fixation may not be necessary for small (Type I) fractures with an intact radial head and intact lateral sided ligaments. Other authors state that small coronoid fractures without elbow instability will not require surgical treatment except when they become symptomatic loose bodies.[17] Clearly, all coronoid fractures require careful long-term follow-up to monitor recovery status and intervene as needed.

The majority of coronoid fractures are Type II, which should be treated surgically based on fracture characteristics.[17,27,29] We found that among patients with Type II fractures alone, patients who received the LMP approach had a higher MEPS and flexion score than those who received the anteromedial approach. However, the causal relationship is uncertain, and it cannot be concluded whether patients who had inferior outcomes received the anteromedial approach or the anteromedial approach actually causes inferior outcomes.

Complications that may occur following treatment include loss of ROM, osteoarthritis, heterotopic ossification, calcification, elbow instability, and paresthesias.[27] Younger patients tend to have fewer post-treatment symptoms.[17] Early postoperative mobilization should be performed, as prolonged immobilization (3–4 weeks) is associated with poor results, including loss of ROM, pain, persistent stiffness, and loss of function.[17,27] Early physical therapy and ROM exercise may help to strengthen muscle groups that play a role in muscle stability.[17,29]

The present systematic review has several limitations, especially that all included studies were retrospective. Another limitation is that only 6 studies with a relatively small patient number were included in the present systematic review. These limitations suggest an urgent need for future well-designed prospective studies. In addition, although we have performed a quantitative analysis to compare patients' functional outcomes between LMP and anteromedial approaches, it remains inconclusive because cross-sectional retrospective analysis does not allow inference of causal relationship. Finally, complications were not evaluated in this review.

5. Conclusion

Surgical treatments for isolated ulnar coronoid fractures result in good functional outcomes generally. Whether the LMP approach leads to more favorable functional outcomes than the anteromedial approach remains inconclusive. Further well-designed prospective studies with larger samples are highly warranted.

Author contributions

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