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The treatment of anteromedial coronoid facet fractures: a systematic review

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Background: Fractures of the anteromedial facet (AMF) of the coronoid process are caused by a varus posteromedial rotational injury force, leading to instability in the ulnohumeral joint. AMF fractures are usually accompanied by avulsion of the lateral ulnar collateral ligament (LUCL). O'Driscoll's description and classification of AMF coronoid fractures has increased awareness and interest in this injury, but the optimal treatment has yet to be decided.

Methods: We systematically reviewed the available literature searching electronic databases, MEDLINE using the PubMed interface and Embase. The primary objective was to determine outcome scores but also complication and revision rates depending on the fracture and its therapy in order to gain a more comprehensive picture. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were applied.

Results: Initially, 304 publications were identified. Finally, 10 studies were left for inclusion, all of them retrospective in design, comprising 128 patients; the majority of them were male (75.7%). A total of 114 patients (89.1%) were treated surgically and 14 patients (10.9%) were treated conservatively. Among the surgically treated patients, 70.2% were treated with LUCL refixation. The average Mayo Elbow Performance Score of the surgically treated patients was 91.5 points. The average Mayo Elbow Performance Score of the conservatively treated patients was 91.4 points. A total of 10 patients (7.8%) required reoperation.

Conclusion: Surgery of AMF fractures leads to a satisfactory functional outcome in the vast majority of patients independent of the subtype. An algorithm for LUCL fixation is still pending. Conservative treatment may be considered under strict preconditions, especially for nondisplaced subtype 1 and 2 fractures, as these fractures show satisfactory functional outcomes when treated nonoperatively.

Level of evidence: Level IV; Systematic Review

Keywords: Anteromedial coronoid facet fracture; therapy; treatment; outcomes; systematic review; posteromedial rotatory instability; lateral ulnar collateral ligament

During the last 2 decades there has been increasing interest into the pathoanatomy and treatment of coronoid fractures. [8,9,13,24] Biomechanical and clinical studies emphasized their crucial role as an anterior buttress of the elbow joint, preventing the joint's dislocation.[6,7,14,17,22] Regan and Morrey's classification of coronoid fractures in 1989 referred to the size of the fragment, as measured on lateral radiographs.[19] In 2003, O'Driscoll et al[15] recognized that the anatomic location and the injury pattern need to be addressed as well: the injury pattern (varus posteromedial rotational injury mechanism) is associated with the coronoid fracture (anteromedial facet [AMF]).

Fractures of the AMF of the coronoid process lead to instability in the ulnohumeral joint. They are usually

Institutional review board approval was not required for this systematic review.

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accompanied by avulsion of the lateral ulnar collateral ligament (LUCL) and/or the medial collateral ligament.[9,21,23] AMF fractures comprise 3 different subtypes, according to the O'Driscoll classification: subtype I involves the rim, subtype II involves the rim and the tip, and subtype III involves the rim and the sublime tubercle.[15]

O'Driscoll's description and classification of AMF coronoid fractures has increased awareness and interest in this injury; however, the optimal treatment for AMF fractures is not yet conclusively established.

Nevertheless, tackling these issues is essential as varus, posteromedial rotatory instability, accompanying AMF fracture, leads to rapidly progressive osteoarthritis if not adequately treated. We decided to perform a systematic review of the literature in order to gain a more comprehensive and up-to-date overall picture on AMF fractures, their treatment (surgical or conservative), outcomes, and possible risks and complications.

Methods

In order to ensure methodical transparency and objectivity, the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) guidelines were applied.

Inclusion criteria

The research included (1) all study designs, (2) all levels of evidence, (3) studies published in English and German language since (4) the start of literature in the concerning electronic databases and (5) all studies O'Driscoll classified as anteromedial coronoid facet fractures (6) providing outcome data.

Exclusion criteria

The research excluded (1) cadaveric studies, (2) biomechanical studies, (3) anatomically descriptive studies, (4) studies providing only the Regan-Morrey classification, (5) studies that involved only O'Driscoll classified tip and basal coronoid fractures, and (6) studies that provided no follow-up data.

Search strategy

Electronic databases, MEDLINE using the PubMed interface and Embase, were investigated using the search terms and Boolean operators "anteromedial AND coronoid AND facet AND fracture*," "anteromedial AND coronoid AND fracture*," "varus AND posteromedial AND instability," and "coronoid AND Type 2 AND fracture*." The publications found via Embase were filtered additionally, as the sources "Medline" and "Embase and MEDLINE" were excluded in order to make sure that previously found articles (found via PubMed) were not screened twice. At this stage, we focused on finding as many papers as possible that may be relevant (sensitivity), rather than seeking for high specificity, in order to not miss anything. The search was completed on April 30, 2020.

Study selection

The studies identified were then independently scanned by 2 reviewers (FL and TL). The titles and abstracts were screened for each publication, and, if necessary, the full text was assessed for suitability to identify publications meeting the inclusion criteria. This decision-making process is illustrated in the PRISMA-adapted flow diagram (Fig. 1). In case of any disagreement, a third reviewer (LPM) was consulted and borderline cases were resolved by consensus decision.

Data extraction

The data of the publications suitable for inclusion were extracted into prefabricated tables, considering title, number of patients, mean age, mean follow-up time, gender, fracture characteristics (O'Driscoll AMF subtypes), therapy (coronoid and LUCL treatment), outcome scores (Mayo Elbow Performance Score [MEPS] and Quick Disabilities of Arm, Shoulder, and Hand), and complication and revision rates. The primary objective was to determine outcome scores but also complication and revision rates depending on the fracture and its therapy. The secondary objective was to investigate whether the outcome scores differ concerning the different AMF subtypes and the therapy (surgical vs. conservative)

Results

Study selection

The initial search covered 304 publications. After the removal of duplicates and the exclusion of abstracts not fitting the inclusion criteria, 33 full texts were assessed for eligibility. Of them, 23 were excluded for reasons outlined in the PRISMA-adapted flow diagram (Fig. 1), leaving 10 publications including a total of 128 patients for inclusion.

Study characteristics

The principal characteristics of the publications included are shown in Table I. The mean age of the 128 patients reported was 44 years; approximately three-quarters of them (75.7%) were male. They were followed up at an average of 34 months. The specific AMF subtype was reported in 115 patients: 6.1% had a subtype 1 fracture, 61.7% had a subtype 2 fracture, and 32.2% had a subtype 3 fracture.

Therapy

Altogether, 114 patients (89.1%) were treated surgically and 14 patients (10.9%) were treated conservatively. The surgical procedure of the concerning patients was available in 92 cases and is shown in Table II. The most frequently used method for fixation was a buttress plate in 67 of these

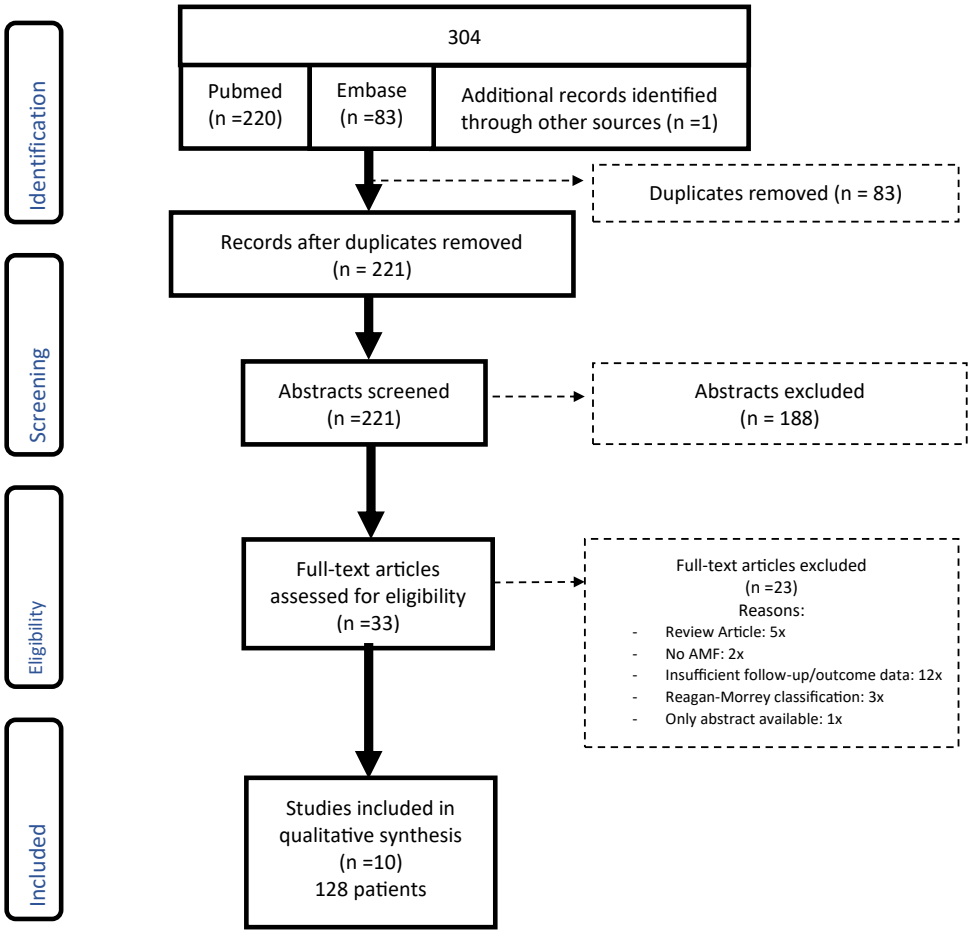

Figure 1 PRISMA-adapted flow diagram illustrating the study selection. *AMF*, anteromedial facet.

Table I Summary of the studies included

First author (yr)	Number of patients	Mean age (range) (yr)	Mean follow-up (range) (mo)	Gender (% male)	Subtype 1*	Subtype 2*	Subtype 3*
Chen (2015)[5,†]	10	32 (26-43)	15 (12-24)	70	NA	NA	NA
Chen (2018)[4]	20	44 (26-67)	28 (24-46)	75	2	9	9
Ge (2016)[10,†]	4	47 (39-55)	24 (12-38)	50	–	2	2
Klug (2019)[11]	24	48 (19-78)	44 (12-86)	83	–	11	13
Liu (2018)[12]	22	48	32 (26-62)	68	1	19	2
Park (2015)[16]	11	42 (29-62)	31 (24-38)	64	2	4	5
Rausch (2020)[18,†]	6	45 (28-62)	11 (5-22)[‡]	100	–	3	3
Rhyou (2014)[20]	18	39 (26-71)	37 (12-70)	89	2	14	2
Chan (2016)[3]	10	49 (28-61)	50 (12-83)	60	–	9	1
Van Der Werf (2010)[25,†]	3	52 (41-68)	52 (41-68)	100	NA	NA	NA
	128	**44**	**34**	**75.7**	**6.1%**	**61.7%**	**32.2%**

NA, not available.
* O'Driscoll classification.
† Only anteromedial facet (AMF) considered.
‡ Value applies to the whole study and could not be converted to AMF's only.

Table II Summary of the therapeutic methods

First author (yr)	Therapy	Coronoid fixation	LUCL fixation
Chen (2015)[5,*]	Surgery	10 plates, 4 additional screws	10
Chen (2018)[4]	Surgery	20 NA	3
Ge (2016)[10,*]	Surgery	4 plates	4
Klug (2019)[11]	Surgery	24 plates, 10 additional screws	16
Liu (2018)[12]	Surgery	14 plates, 4 additional screws and 2 additional screws + K-wire 6 suture anchors, 4 additional K-wires 1 screw 1 lasso suture	22
Park (2015)[16]	Surgery	9 plates, 2 not addressed	11
Rausch (2020)[18,*]	Surgery	6 plates	5
Rhyou (2014)[20]	Surgery and conservative	7 K-wires 4 not addressed 2 plates 2 screws 2 NA 1 conservative	9
Chan (2016)[3]	Conservative	–	–
Van Der Werf (2010)[25,*]	Conservative	–	–

NA, not available; *LUCL*, lateral ulnar collateral ligament.
* Only anteromedial facet considered.

92 patients (72.8%), of whom 20 received at least 1 additional screw.

For subtype 1 fractures, the individual surgical technique concerning the patient's subtype was available in 5 cases. In 4 patients, only the LUCL was repaired using suture anchors while not addressing the coronoid. In 1 patient, the LUCL and the coronoid were fixed using suture anchors each. For subtype 2 and 3 fractures, the individual surgical technique concerning the patient's subtype was available in 79 cases. In 77 of these 79 patients, the coronoid was addressed. In the remaining 2 cases, only the LUCL was addressed using suture anchors.

Handling of the LUCL is also displayed in Table II. Among the 114 surgically treated patients, 80 (70.2%) were treated with LUCL refixation.

Rhyou et al[20] reported 1 patient with a 5 mm subtype 2 fracture treated conservatively. Varus stress testing under fluoroscopy with forearm rotation was performed to confirm the ulnohumeral joint's congruency and a firm end point resistance, provided that the fracture fragment was <5 mm. In the study of Chan et al,[3] 9 patients with a subtype 2 fracture and an average fragment size of 5 mm were treated nonoperatively. Another patient had a 9 mm subtype 3 fracture; however, it was only minimally displaced (1 mm).[3] Radiologically, preconditions for conservative treatment comprised ulnohumeral joint congruency seen on radiographs and computer tomography (CT) scans. Clinical preconditions comprised a stable arc of elbow motion to a minimum of 30° of extension within the first 2 weeks after injury and negative hyperpronation and gravity varus stress testing. Van Der Werf et al[25] described 3 patients treated conservatively. Concentric joint reduction seen on CT scans and 3-dimensional reconstructions was preconditioned for conservative treatment.

Functional outcomes

The average MEPS of the surgically treated patients was 91.5 points (Table III). Accordingly, 68 patients (59.6%) had excellent scores, 35 patients (30.7%) had good scores, 9 patients (7.9%) had fair scores, and 2 patients (1.8%) had poor scores. A total of 6 studies reported individual patient scores in relation to the different subtypes: subtype 1 (n = 5) with a mean MEPS of 97.0 points, subtype 2 (n = 52) with a mean MEPS of 90.7 points, and subtype 3 (n = 27) with a mean MEPS of 94.2 points.[10-12,16,18,20]

The average MEPS of the conservatively treated patients was 91.4 points. Therefore, 9 patients (64.3%) scored excellent, 4 patients (28.6%) scored good, and 1 patient (7.1%) scored poor.

Complications

A total of 10 patients (7.8%) were reported to require reoperation for reasons stated in Table IV. In 6 of 10 studies included, no patient was reported to be in need of reoperation.[3,5,16,18,20,25] Complication rates ranged from 0% to 25%. Seven of 10 reoperations were arthrolyses to treat stiffness that frequently attends this type of severe elbow injury. Common complications not requiring reoperation involved 13 cases of heterotopic ossification

Table III Summary of the outcome scores

First author (yr)	Mean MEPS, points (range)	MEPS detail	Mean (q)DASH score, points (range)
Chen (2015)[5,*]	93 (72-100)	6× excellent, 3× good, 1× fair	NA
Chen (2018)[4]	87.75 ± 12.51 (55-100)	10× excellent, 8× good, 1× fair, 1× poor	qDASH: 7.05 ± 6.19 (0-22)
Ge (2016)[10,*]	88.75 (75-100)	2× excellent, 2× good	DASH: 8.125 (0-22.5)
Klug (2019)[11]	98 (85-100)	21× excellent, 3× good	DASH: 7 (0-23)
Liu (2018)[12]	88.1 ± 12.2 (55-100)	8× excellent, 10× good, 4× fair	NA
Park (2015)[16]	89 ± 11 (65-100)	4× excellent, 6× good, 1× fair	NA
Rausch (2020)[18,*]	75.83 (40-100)	2× excellent, 1× good, 2× fair, 1× poor	qDASH: 19.99 (0-52.27)
Rhyou (2014)[20]	98 (85-100)	16× excellent, 2× good	DASH: 5.6 (0-35.8)
Chan (2016)[3]	94 ± 8	6× excellent, 4× good	DASH: 7 ± 9
Van Der Werf (2010)[25,*]	80 (40-100)	2× excellent, 1× poor	DASH: 17.2 (0-49.1)
	Mean surgical MEPS: 91.5		
	Mean conservative MEPS: 91.4		

MEPS, Mayo Elbow Performance Score; *(q)DASH*, (Quick)Disabilities of Arm, Shoulder, and Hand; *NA*, not available.
* Only anteromedial facet considered.

(10.2%), osteoarthritis in 19 cases (14.8%), and 3 cases of ulnar nerve neuropathy (2.3%); however, 2 cases resolved after 3 months, whereas 1 patient still felt numbness in the ulnar-innervated area of the hand.[16] One patient (0.8%) with local and superficial infections was treated with antibiotics and recovered.[12]

Discussion

Fractures of the AMF of the coronoid process are mostly caused by a varus posteromedial rotational injury force, leading to potential instability in the ulnohumeral joint, and are usually accompanied with avulsion of the LUCL.[9,21,23]

Table IV Summary of the complications

First author (yr)	Reoperations: number (%)	Reoperations: number and method	Complications not requiring further reoperations: number and cause
Chen (2015)[5,*]	0 (0)	–	1 HO, 1 "retrogression": mild degenerative change
Chen (2018)[4]	1 (5)	1 coronoid refixation	1 HO
Ge (2016)[10,*]	1 (25)	1 arthrolysis	–
Klug (2019)[11]	5 (20.8)	5 arthrolysis and implant removal	7 HO, 3 OA (2 grade 1, 1 grade 2),[†] 1 ulnar nerve neuropathy (resolved after 3 mo)
Liu (2018)[12]	3 (13.6)	1 arthrolysis 1 removal of a shifted K-wire 1 ulnar nerve neurolysis and transposition	4 HO, 6 OA (4 grade 1, 2 grade 2),[†] 1 local and superficial infection (resolved)
Park (2015)[16]	0 (0)	–	2 OA, 1 joint incongruity, 2 ulnar nerve neuropathy (1 resolved after 3 mo)
Rausch (2020)[18,*]	0 (0)	–	–
Rhyou (2014)[20]	0 (0)	–	8 OA (7 grade 1, 1 grade 2)[†]
Chan (2016)[3]	0 (0)	–	–
Van Der Werf (2010)[25,*]	0 (0)	–	–
	10 (7.8)		

HO, heterotopic ossification; *OA*, osteoarthritis.
* Only anteromedial facet considered.
† According to the Broberg and Morrey scale.

Current literature suggests surgery to be the treatment of choice, but this is still debatable.[4,5,10-12,16,18,20] These findings are supported by the studies included as 114 patients (89.1%) were treated surgically, whereas only 14 patients (10.9%) received conservative treatment.

This systematic review shows that satisfactory results can be achieved with surgical management of AMF fractures. With regard to the MEPS of the surgically treated patients, outcomes were satisfactory with a mean score of 91.5 points and almost 60% of the patients scoring excellent. These results apply regardless of the subtype according to the O'Driscoll classification concerning the studies where individual data were available: subtype 1 (n = 5) with a mean MEPS of 97.0 points, subtype 2 (n = 52) with a mean MEPS of 90.7 points, and subtype 3 (n = 27) with a mean MEPS of 94.2 points.

The study of Klug et al[11] covered the most patients (n = 24) with the longest follow-up period (44 months) among the studies of surgical intervention. Plate fixation of the coronoid was done in all cases; screws were additionally used in 10 patients. The mean MEPS amounted to 98 points with 21 patients scoring excellent and 3 patients scoring good. Remarkably, the reoperation rate was 20.8% compared with an average of 7.8% in this systematic review. However, it should be emphasized that they were all due to arthrolysis and implant removal, which could possibly be related to the longer follow-up period compared with the other studies.

Several techniques for the fixation of the coronoid fracture have been introduced. They are displayed in this review. In the vast majority of cases, the coronoid process was fixed with plates or plates and additional screws. The combination of the limited number of patients and varying surgical fracture management does not allow a final assessment on whether one procedure is superior to another due to their heterogeneity and the impossibility of subgroup formation.

Based on the results—an average MEPS of the surgically treated patients of 91.5 points as well as only marginal differences respecting the subtypes—no major differences regarding the outcomes were identified. The reported complications need to be viewed critically as they differed by up to 25%: further investigations will be necessary in order to gain a final judgment.

Biomechanical studies emphasized the importance of the LUCL for the joint's stability and congruence in posteromedial rotatory instability of the elbow: Bellato et al[2] recommended addressing the LUCL in order to prevent subluxation and incongruity. Moreover, previous authors indicated that little displaced AMF subtype 1 fractures might be sufficiently treated with isolated LUCL refixation, not addressing the actual coronoid fracture.[1,17] In the current systematic review, Park et al[16] treated 2 patients with AMF subtype 1 fracture with LUCL repair only. Both patients had an MEPS of 100 points; the authors concluded that the sole LUCL repair was sufficient to maintain elbow stability. In case of fracture fragments smaller than 5 mm, Rhyou et al[20] performed varus stress testing under fluoroscopy with forearm rotation. If the ulnohumeral joint was not congruent, the LUCL was repaired and the fluoroscopy testing repeated. In this way, 2 AMF subtype 1 fractures (average MEPS of 92.5 points) as well as 2 AMF subtype 2 fractures (average MEPS of 100 points) were treated: entirely with satisfactory results.

Overall, 80 cases (70.2%) were treated with LUCL fixation among the 114 surgically treated patients; however, general guidelines are lacking. There appears to be a consensus that examination under anesthesia with fluoroscopy to look for signs of instability is recommended.

Nonoperative therapy may be a potential treatment option, provided that the fracture is small, minimally displaced and the joint remains congruent and stable. The average MEPS of the conservatively treated patients was 91.4 points, and approximately 64% scored excellent. Particularly, the study of Chan et al[3] showed that conservatively managed subtype 2 AMF fractures can lead to satisfactory clinical results, given the precondition that the patient shows concentric joint reduction seen on CT scans, a stable range of motion to a minimum of 30° of extension, and normal findings on hyperpronation and gravity varus stress testing. These results are supported by further, even smaller case series.[20,25] Rhyou et al[20] treated 1 AMF subtype 2 fracture conservatively given the precondition that the fracture fragment was smaller than 5 mm and the joint appeared congruent in varus stress testing under fluoroscopy. Among the studies assessing conservative treatment, the study of Chan et al[3] covered the most patients (n = 10) with the longest follow-up time (50 months). The average MEPS was 94 points with 6 patients scoring excellent and 4 patients scoring good. No complication was reported. It may be noted that the study pool remains insufficient to gain a final statement, as the total number of patients included (n = 128) is rather small, and despite the initial search covering 304 publications, only 10 were suitable for inclusion. However, the conservatively managed patients (average MEPS of 91.4 points) did not score remarkably worse than patients treated surgically (average MEPS of 91.5 points). Hence, conservative management should always be considered a possible alternative, given that the fracture appears small, minimally displaced, and the elbow joint remains radiologically congruent and clinically stable.

Limitations of our systematic review contain the retrospective design of all studies included, not allowing a predetermined treatment procedure, and the relatively small number of patients (n = 128). The conservative cohort was comparably under-represented (10.9%). The role of the medial collateral ligament was not further addressed in the publications included; however, it has important

implications for reduction and repair, as biomechanical studies showed, and should deserve more attention in the future.

Conclusion

The results of this systematic review indicate that most patients experience satisfactory functional outcomes after surgery for AMF fractures independent of the subtype. A complication rate requiring reoperation of 7.8% in this study cohort should be discussed. Although in 70.2% of patients the LUCL was fixed, an algorithm for fixation is still pending. Under certain conditions, a conservative treatment may be considered, especially for nondisplaced AMF subtype 1 and 2 fractures.

Disclaimer

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