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Are outcomes after fixation of distal humerus coronal shear fractures affected by surgical approach? A systematic review and meta-analysis

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A R T I C L E I N F O

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Level of evidence: Level IV; Systematic Review

Background: Surgical management of coronal shear fractures of the distal humerus is associated with a high rate of complications. Several surgical approaches have been described to address these fractures. The complication profiles associated with each approach have not previously been compared, and that is the aim of the present study.

Methods: A systematic review of the literature was performed to identify all studies addressing coronal shear fractures of the distal humerus published between 2001 and January 2022. Of the 189 articles identified, 45 met the criteria for inclusion. Summaries of continuous data were calculated using the inverse variance method for pooling with random effects models. Fixed effects model estimates were reported unless significant heterogeneity was observed between studies. A subset of 6 studies reported the surgical approach and complications associated with the operative management of capitellar shear fractures without posterior comminution. The complication profiles of the extended lateral and anterolateral approaches were compared.

Results: The 45 studies included yielded 899 patients. The average age was 44.9 years (95% confidence interval [CI]: 39.7 to 50.2). The fracture type was Dubberley A in 38% (n = 342), Dubberley B in 33% (n = 300), and not reported in the remainder. The reoperation rate was 13.8% (95% CI: 9.6% to 19.5%). Pooled complication rates included post-traumatic arthritis in 21.2% (95% CI: 18.0% to 24.9%), heterotopic ossification in 12.0% (95% CI: 9.2% to 15.6%), nerve injury in 7.8% (95% CI: 5.6% to 10.9%), and avascular necrosis in 7.4% (95% CI: 5.3% to 10.2%). The complication rate in noncomparative studies was 25.8% following the lateral approach and 16.7% following the anterolateral approach. Reported complications following the anterolateral approach were pain (9.5%) and nerve injury (7.1%). Reported complications following the lateral approach included arthritis (9.1%), heterotopic ossification (6.1%), avascular necrosis (4.5%), instability (3.0%), nerve injury (1.5%), and wound issues (1.5%).

Discussion and Conclusion: Complications are common following operative management of capitellar shear fractures. In noncomparative studies, the complication rate was higher following the extended lateral compared to the anterolateral approach for Dubberley A fractures. Additionally, the reported complications following the extended lateral approach may impact long-term outcomes. Insufficient comparative evidence currently exists to recommend one approach over the other. High-quality comparative studies are needed.

Partial articular shear fractures of the distal humerus involving the capitellum and the trochlea were first described by McKee et al[27] and present a rare but challenging problem to the orthopedic surgeon. Open reduction and internal fixation (ORIF) has emerged as the treatment of choice for displaced fractures of the capitellum and trochlea as conservative management has often produced unsatisfactory results.[21,31,35] However, a high complication rate and reoperation rate have been reported following operative management.[9,33] This may be explained by the complex fracture pattern, limited bone stock available for fixation, as well as difficulties in exposure secondary to the regional anatomy.

Institutional Review Board approval was not required in this systematic review and meta-analysis of de-identified, published data.

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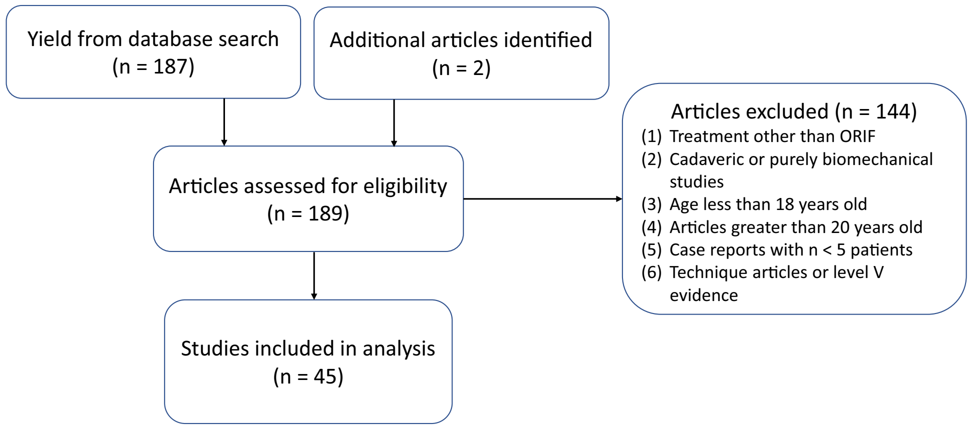

Figure 1 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart.

Numerous classification systems have been proposed for the characterization of distal humerus articular fractures. Among those commonly referenced are the Bryan and Morrey classification[5] and the Dubberley classification.[9] The Dubberley classification is of particular use to the surgeon as this system considers the medial extent of the articular fragment as well as the presence of posterior comminution, both of which must be recognized to determine the optimal surgical approach. While various surgical approaches have been described including lateral (EL), posterior, and anterolateral (AL), the lateral approach has classically been the most utilized. This is in part due to its familiarity, safety, and extensile nature, the latter of which affords the ability to address posterolateral comminution through the same incision. However, the lateral approach may compromise visualization of the anterior joint surface, limiting the surgeon's ability to assess and address medial extension into the trochlea. Adequate exposure in these cases often necessitates release of the lateral collateral ligament. The AL approach has gained popularity recently for the management of fractures confined to the anterior joint surface as it offers the potential advantages of a better exposure of the anterior joint surface, a more perpendicular trajectory for screw placement, and preservation of the lateral collateral ligament.[3]

To date, few studies have directly compared the complications associated with various surgical approaches to the capitellum with available data limited to retrospective case series. Therefore, the purpose of the present study was to perform a systematic review of the literature and meta-analysis to more clearly define the overall complication rate associated with the fixation of coronal shear fractures of the capitellum, with a consideration of the impact of the surgical approach on the complication profile.

Materials and methods

In accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines, a search of PubMed, Medline, EMBASE, and Cochrane Libraries was performed to identify relevant literature through January, 2022. The search terms included "capitellum AND fracture," "capitellar AND fracture," "capitellum AND shear," "capitellar AND shear," or "coronal AND shear." The initial search yielded 187 results. This list was narrowed for the following reasons: (1) management was other than ORIF, (2) the study was cadaveric-based or purely biomechanical, (3) patient age was less than 18 years, (4) the articles were historical (greater than 20 years), (5) case series with less than 5 patients, or (6) the work was a technique article or level V evidence. After these exclusion criteria were applied, 43 studies met the eligibility criteria. These studies were carefully examined and cross-referenced, which yielded an additional two studies. A total of 45 studies were included in the final analysis (Fig. 1).

Patient demographic data, fracture morphology, surgical approach, fixation construct, and complications were assessed. All data were transferred into an electronic spreadsheet and descriptive statistics were performed for all compiled information. A subset analysis was performed to assess the complications following the AL approach or the EL approach in the management of Dubberley A fractures (those without posterior comminution).

Statistical analysis

Summaries of continuous data, including patient age and length of follow-up, were calculated using the inverse variance method for pooling with random effects models. Pooled estimates of the study outcomes were calculated using the inverse variance method. Fixed effects model estimates were reported unless significant heterogeneity was observed between studies. If significant heterogeneity was observed, random effects estimates were reported. Heterogeneity was calculated with the I^2 statistic. All analyses were performed using the *meta* package for R (R Foundation for Statistical Computing, Vienna, Austria).

Results

Demographics

A total of 899 patients from the 45 studies reviewed were included in the analysis. One study had level I evidence, 2 had level III evidence, and 42 studies had level IV evidence (Table I). The average patient age was 44.9 years (95% confidence interval [CI]: 39.7 to 50.2) with 54% female. The average follow-up time was 29.7 months. (standard deviation: 23.0 to 36.5). Fracture morphology was Dubberley A in 342 cases (38%), Dubberley B in 300 cases (33%), or not reported (29%) (Table II).

Complications

Pooled complication rates were investigated for the most frequently reported complications (Table III, Table IV). Posttraumatic arthritis (PTA) was reported in 21.2% (95% CI: 18.0% to

Table I
Study demographics and baseline characteristics.

Study	Level of evidence	N	F:M	Age (range, SD)	Injury mechanism (mechanical fall, traffic accident, other*)	Bryan-Morrey (1,2,3,4)	Dubberley (total A, B)	Other classification	Study follow-up (SD)
Ashwood et al. 2010[1]	IV	26	13:13	39.4 (22-76, 13.5)	21,5,0	NR	16,10	NR	46
Ballesteros-Betancourt et al. 2020[2]	IV	8	4:4	66 (53-76, 5.75)	NR	NR	4,4	NR	33
Bilsel et al. 2013[3]	IV	18	12:6	45.3 (16-70, 13.5)	14,0,4	7,0,5,6	NR	NR	43.6 (38.1)
Brouwer et al. 2011[4]	IV	30	21:9	49 (17-75, 14.5)	25,2,3	NR	6,24	NR	34
Chang et al. 2020[6]	IV	9	NR	(26-70)	NR	NR	NR	NR	18
Demir et al. 2020[7]	IV	10	6:4	43.8 (34-72, 11.1)	10,0,0	NR	0,10	NR	59.6 (38.79)
Dietz et al. 2005[8]	IV	7	3:4	45 (21-85, 16)	NR	7,0,0,0	NR	NR	30.3
Dubberly et al. 2006[9]	IV	28	24:4	43 (20-71, 12.75)	28,0,0	NR	13,15	NR	56 (33)
Durakbasa et al. 2013[10]	IV	15	10:5	36 (11-76, 16.25)	9,3,3	NR	9,6	NR	50
Garg et al. 2020[12]	IV	10	2:8	29.3 (21-42, 5.25)	4,6,0	NR	NR	NR	13.8
Goodman et al. 2005[13]	IV	8	6:2	56 (18-80, 15.5)	NR	NR	NR	NR	14
Guitton et al. 2009[14]	IV	27	NR	NR	NR	NR	3, 24	Ring: 1 (1); 2 (1); 3 (9); 4 (15); 5 (1)	NR
He et al. 2019[16]	IV	20	12:8	48.3 (16-76, 15)	13,7,0	NR	17,3	NR	42.5
Heck et al. 2012[17]	IV	15	11:4	35.7 (13-72, 14.75)	NR	7,3,2,3	13,2	NR	58.5
Hussain et al. 2018[18]	IV	15	0:15	27.5	8,0,0	11,1,1,2	NR	NR	22.5
Imatani et al. 2001[19]	IV	6	4:2	47 (38-66, 7)	4,2,0	NR	NR	NR	40.3
K.C. et al. 2020[20]	IV	22	8:14	35.86 (20-64, 11.18)	8,9,5	NR	22,0	NR	9.36 (2.4)
Lopiz et al. 2016[22]	IV	20	13:7	71 (66-79, 3.25)	19,0,1	NR	15,5	NR	48
Lu et al. 2021[23]	IV	24	7:17	44.9 (19-75)	12,6,6	NR	0,24	NR	19.6 (7.7)
Lu et al. 2016[24]	IV	47	16:31	56.4	42,0,5	NR	27,20	NR	18.1
Mahirogullari et al. 2006[25]	IV	11	3:8	27.5 (17-43, 6.5)	11,0,0	11,0,0,0	NR	NR	23.4
Marinelli et al. 2018[26]	IV	45	13:32	52 (15-88, 18.25)	NR	NR	17,28	NR	39.6 (27.6)
Mighell et al. 2010[28]	IV	18	16:2	45 (20-68, 12)	NR	NR	18,0	NR	25.5
Mukohara et al. 2021[30]	III	25	22:3	57 (12-79, 20)	21,4,0	NR	12,13	NR	15 (9)
Ravishankar et al. 2017[32]	IV	33	11:22	37.9 (12-70, 14.5)	10,22,1	17,3,2,11	5,6	NR	24.6
Ring et al. 2003[33]	IV	21	19:2	50 (20-74, 13.5)	15,3,3	NR	12,9	Ring: 1 (3); 2 (2); 3 (5); 4 (4); 5 (7)	40
Rotini et al. 2011[34]	IV	10	7:3	46.4 (15-65, 12.5)	NR	3,1,0,6	NR	NR	31.7
Ruchelsman et al. 2008[36]	IV	16	13:3	40 (11-67, 17)	NR	6,0,2,8	NR	NR	27 (19)
Sano et al. 2005[37]	IV	6	6:0	51 (12-78, 16.5)	5,0,1	NR	NR	Grantham: 2A (2); 2B (1); 2C (1); 3A (2)	67.2
Shergold et al. 2022[38]	III	45	31:14	53 (19-86)	NR	NR	19,26	NR	28
Singh et al. 2010[40]	IV	14	5:9	33 (16-46, 7.5)	11,0,3	10,1,3,0	NR	NR	57.6
Singh et al. 2012[39]	IV	10	3:7	32 (18-36, 4.5)	4,6,0	NR	NR	NR	24.4
Song et al. 2020[41]	IV	52	17:35	40.4 (23-62, 9.75)	52,0,0	NR	40,12	NR	17.6
Sultan et al. 2017[42]	IV	15	11:4	35 (20-48, 7)	15,0,0	9,0,0,6	NR	NR	42.5
Tanriverdi et al. 2020[43]	IV	21	8:13	39 (18-63)	NR	14,0,3,4	NR	NR	45
Tarallo et al. 2015[44]	IV	8	2:6	50 (37-64, 6.75)	8,0,0	NR	3,5	NR	30
Tarallo et al. 2021[45]	IV	24	16:8	50.2 (18-71)	NR	NR	10,14	NR	30
Teng et al. 2020[46]	IV	19	11:8	44.6 (19-72)	14,5,0	NR	12,7	NR	17.1

Table I (*continued*)

Study	Level of evidence	N	F:M	Age (range, SD)	Injury mechanism (mechanical fall, traffic accident, other*)	Bryan-Morrey (1,2,3,4)	Dubberley (total A, B)	Other classification	Study follow-up (SD)
Tomori et al. 2022[47]	IV	8	8:0	76.3 (66-83, 5.1)	8,0,0	NR	1,7	NR	23.6 (13.9)
Vaishya et al. 2016[48]	IV	16	6:10	32 (18-50, 8)	14,0,2	10,5,0,1	NR	NR	27.6
Wang et al. 2019[49]	IV	15	10:5	44.3 (22-71, 12.25)	4,8,3	NR	0,15	NR	32.5
Yoshida et al. 2021[50]	IV	16	13:3	49 (11-78)	16,0,0	NR	10,1	NR	23.5
Yu et al. 2019[52]	I	26	15:11	49 (32-59, 6.75)	19,7,0	NR	26,0	NR	20.5 (6)
Yu et al. 2018[51]	IV	15	9:6	42 (19-64, 11.25)	10,5,0	NR	15,0	NR	29 (4)
Zhang et al. 2020[53]	IV	34	26:8	49.6 (35-64.2, 7.3)	14,0,20	NR	0,34	NR	44.9 (34.6)

SD, standard devitaion.
*other mechanisms include blunt trauma, biking, fall from a height.

Table II
Study summary.

Characteristics	
No. of studies	45
No. of patients	899
Age, y, mean (95% CI)	44.9 (39.7 to 50.2)
Sex	
Female	485 (54%)
Male	372 (41%)
Not reported	42 (5%)
Fracture type (Dubberley)	
A	342 (38%)
B	300 (33%)
Not reported	257 (29%)
Follow-up, mo, mean (SD)	29.7 (23.0 to 36.5)

CI, confidence interval; *SD*, standard deviation.

24.9%) and reoperation was reported in 13.8% (95% CI: 9.6% to 19.5%), most commonly to address symptomatic hardware. Other frequently reported complications included heterotopic ossification (HO) in 12.0% (95% CI: 9.2% to 15.6%), nerve injury in 7.8% (95% CI: 5.6% to 10.9%), avascular necrosis (AVN) in 7.4% (95% CI: 5.3% to 10.2%), and nonunion in 6.6% (95% CI: 4.6% to 9.2%).

Approach and complications

Approaches used to address capitellum fractures included lateral/extended lateral, anterolateral, and posterior (Table V). Fractures confined to the anterior joint surface (Dubberley A) were most often addressed via either the EL or AL approach, while fractures with posterior comminution (Dubberley B) were addressed via the EL or a posterior approach. Six studies identified the approach to address a Dubberley type A fracture and reported postoperative complications. Studies were limited to those addressing Dubberley A fractures to minimize fracture heterogeneity. These studies included 108 patients undergoing surgery via the lateral approach (n = 66) or via the anterolateral approach (n = 42). The overall complication rate among these studies was 24.2%. The complication rate in noncomparative studies was 25.8% following the lateral approach and 16.7% following the anterolateral approach. Reported complications following the anterolateral approach included pain (9.5%) and nerve injury (7.1%). Reported complications following the lateral approach included arthritis (9.1%), HO (6.1%), AVN (4.5%), instability (3.0%), nerve injury (1.5%), and wound issues (1.5%).

Discussion

Distal humerus coronal shear fractures of the capitellum and trochlea are a challenging injury to manage. ORIF is considered the standard of care for displaced fractures and stable fixation allows for early range of motion. However, a high complication and reoperation rate have been reported, in part because of the often-limited bone stock available for fixation as well as the difficulty in adequately exposing the fracture for surgical fixation. Recent meta-analyses have assessed functional outcomes and complications following operative management of these fractures,[11,15] but the present study is the first to compare the complication profiles of different surgical approaches.

Available literature was reviewed and the reoperation rate following ORIF of these injuries was determined to be 13.8% (95% CI: 9.6% to 19.5%); however, there was considerable heterogeneity in the literature. Post-traumatic arthritis was reported in 21.2% (95% CI: 18.0% to 24.9%) of cases and heterotopic ossification was seen in 12% (95% CI: 9.2% to 15.6%) of cases. A sub-analysis was performed to associate the surgical approach with complication profile in the management of Dubberley A fractures. In attempt to homogenize the fracture patterns, those analyzed were limited to Dubberley A fractures. The aim was to eliminate the confounding effect of Dubberly B fractures, which are known to be associated with worse outcomes.[1,10,26] In noncomparative studies, the overall complication rate was higher following the lateral approach (25.8%) compared to the anterolateral approach (16.7%). Pain (9.5%) and incomplete posterior interosseous nerve (PIN) palsy (7.1%) were more highly associated with the anterolateral approach while post-traumatic arthritis (9.1%), HO (6.1%), and AVN (4.5%) were more likely to be reported after the extended lateral approach. Only one study included in our analysis directly compared the two approaches. The authors reported one case of temporary PIN palsy associated with the anterolateral approach, but had no cases of post-traumatic arthritis, HO, or AVN.[52] It is worth noting that permanent injury of the PIN was not reported in any of the articles. The increased incidence of PIN temporary palsy with the AL approach may be explained by the fact that the PIN is directly in the surgical field during the AL approach. The extensive dissection associated with the EL approach may explain the relatively high rate of HO and AVN following this approach. These complications of PTA, HO, and AVN following the lateral approach have the potential to affect long-term outcomes.

Numerous studies have found Dubberley B fractures to be associated with worse functional outcomes and increased complication rates compared to Dubberley A fractures.[1,4,9,26] Marinelli et al

Table III
Pooled estimates of study complications.

Outcome	No. of studies	Proportion (95% CI)	I^2 (95% CI)
Reoperation, n (%)	37	13.8% (9.6 to 19.5%)	60.2% (42.9% to 72.2%)
Nonunion, n (%)	33	6.6% (4.6% to 9.2%)	0.0% (0.0% to 33.9%)
Arthritis, n (%)	39	21.2% (18.0% to 24.9%)	47.6% (23.8% to 64.0%)
Avascular necrosis, n (%)	33	7.4% (5.3% to 10.2%)	0.0% (0.0% to 17.7%)
Heterotopic ossification, n (%)	32	12.0% (9.2% to 15.6%)	46.2% (18.4% to 64.5%)
Nerve injury, n (%)	26	7.8% (5.6% to 10.9%)	0% (0.0% to 14.9%)

CI, confidence interval.

Table IV
Functional and patients reported outcomes and complications.

Study	N	Total arc ROM	ROM Ex.	ROM Fl.	Total sup.-pro. ROM	Mean MEPI score	"Excellent" outcome	"Good" outcome	Comp. Total	AVN	Arthritis	HO	Nerve injury	Reops.
Ashwood et al. 2010[1]	26	114.7	14.1	128.8	NR	81.3	9	9	8	0	10	0	2	6
Ballesteros-Betancourt et al. 2020[2]	8	128	10	138	NR	NR	NR	NR	1	0	0	0	0	0
Bilsel et al. 2013[3]	18	123.9	8.9	132.8	180	86.7	12	2	1	0	0	1	0	1
Brouwer et al. 2011[4]	30	115	65	145	NR	NR	NR	NR	22	0	8	1	0	5
Chang et al. 2020[6]	9	120	15	135	NR	NR	NR	NR	2	0	2	0	0	0
Demir et al. 2020[7]	10	119.6	17.9	137.5	151.1	95.5	5	3	3	1	1	0	0	1
Dietz et al. 2005[8]	7	106.6	7	113.6	NR	NR	2	1	2	0	2	0	0	0
Dubberly et al. 2006[9]	28	119	19	138	NR	91	NR	NR	27	1	9	0	0	0
Durakbasa et al. 2013[10]	15	NR	NR	NR	NR	83.3	7	2	25	4	6	7	0	0
Garg et al. 2020[12]	10	136	NR	NR	180	96	NR	NR	1	0	0	0	1	0
Goodman et al. 2005[13]	8	NR	NR	NR	NR	84	NR	NR	8	0	0	0	2	2
Guitton et al. 2009[14]	27	NR	NR	NR	NR	NR	NR	NR	8	0	9	0	0	0
He et al. 2019[16]	20	99.6	17.5	117.1	NR	NR	10	7	15	2	6	4	1	14
Heck et al. 2012[17]	15	124	NR	NR	173	90	7	7	15	0	8	0	0	0
Hussain et al. 2018[18]	15	125	7.6	135	NR	NR	10	4	8	0	2	4	0	0
Imatani et al. 2001[19]	6	113.8	14.5	128.3	NR	NR	1	4	2	0	0	0	0	0
K.C. et al. 2020[20]	22	138.41	NR	NR	161.59	90.22	NR	NR	NR	0	0	0	0	0
Lopiz et al. 2016[22]	20	122	8	122	NR	92	14	4	12	1	3	5	1	1
Lu et al. 2021[23]	24	111	8.5	122.5	160.2	89.8	18	5	3	0	0	0	0	0
Lu et al. 2016[24]	47	112	6	118	NR	87.6	31	12	0	0	0	0	0	0
Mahirogullari et al. 2006[25]	11	117	NR	NR	151	93.6	8	3	4	0	0	0	0	0
Marinelli et al. 2018[26]	45	NR	NR	NR	NR	78	12	15	23	2	6	4	6	7
Mighell et al. 2010[28]	18	128	NR	NR	176	NR	12	5	12	3	5	3	0	0
Mukohara et al. 2021[30]	25	120.2	10	130	NR	96.3	18	5	16	3	7	2	1	0
Ravishankar et al. 2017[32]	33	133	NR	NR	151	80.9	14	10	9	2	1	1	0	0
Ring et al. 2003[33]	21	96	27	123	180	NR	4	12	14	0	0	0	2	10
Rotini et al. 2011[34]	10	NR	NR	NR	NR	98	NR	NR	0	0	0	0	0	0
Ruchelsman et al. 2008[36]	16	123	10	133	180	91.6	9	6	11	0	4	6	0	1
Sano et al. 2005[37]	6	131.7	7.5	139.2	180	NR	3	3	0	0	0	0	0	0
Shergold et al. 2022[38]	45	125	10	130	170	NR	NR	NR	14	0	0	1	6	15
Singh et al. 2010[40]	14	124.5	7.5	132	180	NR	10	4	0	0	0	0	0	0
Singh et al. 2012[39]	10	111.5	6	117.5	NR	NR	7	2	1	0	0	1	0	1
Song et al. 2020[41]	52	133	3	136	180	90.6	36	11	13	0	3	2	0	17
Sultan et al. 2017[42]	15	120	10	130	NR	91.33	10	5	2	0	1	0	0	2
Tanriverdi et al. 2020[43]	21	102	NR	NR	165	81.9	9	6	11	3	7	1	0	0
Tarallo et al. 2015[44]	8	125	20	125	180	92	5	3	3	0	0	1	0	1
Tarallo et al. 2021[45]	24	113.1	NR	NR	180	92.1	NR	NR	4	0	1	0	0	3
Teng et al. 2020[46]	19	130.5	NR	NR	167.4	85.8	9	8	4	0	3	1	0	10
Tomori et al. 2022[47]	8	87.5	NR	NR	NR	78.8	1	3	8	1	1	0	0	0
Vaishya et al. 2016[48]	16	122	10	132	NR	NR	10	6	2	0	0	0	1	0
Wang et al. 2019[49]	15	NR	11	123.7	NR	89	12	2	4	1	1	1	0	1
Yoshida et al. 2021[50]	16	NR	NR	NR	NR	83.8	7	6	2	0	0	0	0	1
Yu et al. 2019[52]	26	134	NR	NR	169	92	NR	NR	1	0	0	0	1	0
Yu et al. 2018[51]	15	134	NR	NR	172	93	11	4	5	0	0	0	1	0
Zhang et al. 2020[53]	34	NR	NR	NR	NR	NR	NR	NR	17	0	9	0	0	8

ROM, range of motion; *Ex.*, extension; *Fl.*, flexion; *sup-pro*, supination-pronation; *MEPI*, Mayo Elbow Performance Index; *AVN*, avascular necrosis; *HO*, heterotopic ossification; *reops.*, reoperations.

assessed the outcomes following operative management of 45 consecutive distal humerus shear fractures (17 type A, 28 type B).[26] They report a complication rate of 29% (n = 5) following management of type A fractures compared to 64% (n = 18) following management of type B fractures. PTA (n = 5), ulnar nerve symptoms (n = 5), HO (n = 3), AVN (n = 2), and hardware loosening (n = 2) were all more common following management of type B fractures, while residual instability (n = 2) was more common following management of type A fractures. Brouwer et al also suggested a poor prognosis following management of type 3B fractures, reporting a 44% nonunion rate.[4] Recently, the use of lower profile locking plates in the management of Dubberley B fractures has led to encouraging improvements in outcomes, with multiple studies now reporting excellent functional outcomes and a 100% union rate.[41,49]

Table V
Approaches and fixation methods used.

Study	N	Lateral approach*	Anterolateral approach	Olecranon osteotomy	Posterior approach†	Other approach	Fixation with HCS only‡	Fixation with HCS + provisional fixation§	HO prophylaxis?
Ashwood et al. 2010[1]	26	26	0	0	0	0	11	12	1
Ballesteros-Betancourt et al. 2020[2]	8	0	0	0	0	0	8	0	0
Bilsel et al. 2013[3]	18	16	0	2	0	0	2	13	0
Brouwer et al. 2011[4]	30	0	0	0	0	0	0	17	0
Chang et al. 2020[6]	9	0	0	9	0	0	0	0	0
Demir et al. 2020[7]	10	10	0	0	0	0	0	10	1
Dietz et al. 2005[8]	7	0	0	0	0	7	7	0	1
Dubberly et al. 2006[9]	28	5	14	14	7	3	3	0	1
Durakbasa et al. 2013[10]	15	11	0	2	2	0	14	0	1
Garg et al. 2020[12]	10	0	10	0	0	0	10	0	0
Goodman et al. 2005[13]	8	4	0	4	0	0	0	0	0
Guitton et al. 2009[14]	38	22	0	3	2	1	15	0	0
He et al. 2019[16]	20	14	0	6	0	0	0	0	1
Heck et al. 2012[17]	15	15	0	0	0	0	0	0	1
Hussain et al. 2018[18]	15	15	0	0	0	0	13	0	0
Imatani et al. 2001[19]	6	0	6	0	0	0	6	0	0
K.C. et al. 2020[20]	22	22	0	0	0	0	22	0	0
Lopiz et al. 2016[22]	20	16	1	3	0	0	11	0	0
Lu et al. 2021[23]	24	24	0	0	0	0	0	0	1
Lu et al. 2016[24]	47	47	0	0	0	0	47	0	1
Mahirogullari et al. 2006[25]	11	11	0	0	0	0	11	0	0
Marinelli et al. 2018[26]	45	37	0	8	0	0	0	3	0
Mighell et al. 2010[28]	18	18	0	0	0	0	0	18	0
Mukohara et al. 2021[30]	25	13	1	0	12	0	24	13	0
Ravishankar et al. 2017[32]	33	22	5	6	0	0	25	0	0
Ring et al. 2003[33]	21	14	0	7	0	0	10	11	0
Rotini et al. 2011[34]	10	0	0	0	0	0	10	0	0
Ruchelsman et al. 2008[36]	16	16	0	0	0	0	0	16	0
Sano et al. 2005[37]	6	4	0	2	0	0	6	0	0
Shergold et al. 2022[38]	45	25	0	2	4	14	13	21	0
Singh et al. 2010[40]	14	14	0	0	0	0	14	0	0
Singh et al. 2012[39]	10	10	0	0	0	0	4	2	1
Song et al. 2020[41]	52	52	0	0	0	0	0	0	0
Sultan et al. 2017[42]	15	15	0	0	0	0	15	0	0
Tanriverdi et al. 2020[43]	21	19	0	0	2	0	21	0	0
Tarallo et al. 2015[44]	8	8	0	0	0	0	8	0	0
Tarallo et al. 2021[45]	24	24	0	0	0	0	0	24	0
Teng et al. 2020[46]	19	11	0	2	0	6	0	19	0
Tomori et al. 2022[47]	8	5	1	0	2	0	8	2	0
Vaishya et al. 2016[48]	16	0	16	0	0	0	16	0	0
Wang et al. 2019[49]	15	15	0	0	0	0	0	3	1
Yoshida et al. 2021[50]	16	12	2	0	0	2	11	2	0
Yu et al. 2019[52]	26	14	12	0	0	0	26	0	0
Yu et al. 2018[51]	15	0	15	0	0	0	15	0	0
Zhang et al 2020[53]	34	28	0	6	0	0	0	0	0

HCS, headless compression screws; *HA*, hemiarthroplasty; *HO*, heterotopic ossification.
*Includes Kaplan and extended lateral approaches.
†Posterior approaches that are not olecranon osteotomies.
‡Includes Herbert compression screws, Acutrak, or Mitek.
§Includes k-wire, plate, rod.

This study is not without limitations. The majority of published data regarding capitellum shear fractures consists of retrospective case series, likely due to the rare incidence of this injury.[29] Hence, the studies analyzed in the present study were largely level IV evidence. The distinction of a single surgical approach and the reported complications were requisite for inclusion in the sub-analysis. This limited the sub-analysis to six articles and did not allow comparative statistics.

Conclusions

This meta-analysis demonstrated a high rate of complications associated with ORIF of capitellum shear fractures, including a reoperation rate of 13.8%. While the overall complication rate following ORIF of Dubberley A fractures was higher after the lateral approach compared to the anterolateral approach, matched comparisons could not be performed. Persistent pain and temporary PIN palsy were reported following the anterolateral approach, while post-traumatic arthritis, HO, and AVN were more often reported following the extended lateral approach. Those complications encountered following the extended lateral approach may have a long-term impact on outcomes; however, assessment of long-term outcomes is beyond the scope of this work. Surgeons may be able to utilize this information when counseling patients preoperatively. However, insufficient evidence currently exists to definitively recommend one approach over the other when addressing capitellar shear fractures. High-quality comparative studies are needed.

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