Outcomes, Union Rate, and Complications After Operative and Nonoperative Treatments of Neer Type II Distal Clavicle Fractures

A Systematic Review and Meta-analysis of 2284 Patients

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Background: As nonoperative treatment of Neer type II distal clavicle fractures is associated with nonunion rates up to 33%, operative treatment is frequently advocated. However, evidence is lacking regarding which operative treatment to perform and whether this is superior to nonoperative treatment in terms of functional outcome and complication rate.

Purpose: (1) To evaluate which surgical technique in the treatment of Neer type II distal clavicle fractures is optimal with regard to patient-reported outcomes and union and complication rates. (2) To review nonoperatively treated patients.

Study Design: Systematic review; Level of evidence, 4.

Methods: A systematic review of the literature and meta-analysis were performed on January 27, 2021, in PubMed, Embase, CENTRAL, CINAHL/EBSCO, Web of Science/Clarivate Analytics, and SPORTDiscus/EBSCO. The search included all studies regarding nonoperative and operative treatment of Neer type II distal clavicle fractures with a minimum of 20 patients and follow-up of 12 months. The primary and secondary outcomes were patient-reported outcome measures at 12 months and union, complication, and revision rates.

Results: A total of 59 articles were included involving 2284 patients. Coracoclavicular fixation, hook plate, transacromial pins, alternative plate, tension band wire/K-wire, a combination of surgical techniques, and a nonoperative group were described. Hook plates showed lower Constant-Murley scores as compared with coracoclavicular fixation (standard mean difference, -0.77; 95% Cl, -1.26 to -0.28; P = .002). However, no significant difference was seen when the hook plate was compared with the locking plate and tension band wire/K-wire groups, and no significant difference in union rate was seen among all operative treatment groups. Operatively treated patients had significantly higher union rates than patients treated nonoperatively (standard mean difference: 0.05; 95% Cl, 0.01 to 0.37; P = .004).

Conclusion: Patients treated with hook plates showed significantly lower Constant-Murley scores and higher complication and revision rates as compared with those treated with coracoclavicular fixation, without differences in union rate. Higher Constant-Murley scores were seen in those patients with supplemental coracoclavicular fixation when using locking. Nonoperatively treated patients showed good functional outcome despite the 31% nonunion rate, although future studies are necessary to substantiate this conclusion. When using a locking plate, additional craniocaudal fixation showed significant better functional outcome.

Keywords: clavicle or collar bone; fracture; systematic review; meta-analysis

Distal clavicle fractures (DCFs) are classified according to Neer. Type II implies that the fracture is directly medial to the coracoclavicular (CC) ligaments or between the 2 ligaments with 1 being ruptured. DCFs are associated with a high nonunion rate (33%) if treated nonoperatively.^{11,44-46,53} Therefore, operative treatment is commonly advised. A variety of surgical techniques are described, such as locking plate, hook plate, tension band wire/K-wire (TBW/KW), and transacromial fixation, as well as CC fixation by screw, button device, polydioxanone suture (PDS) banding, and titanium cable. Because there is no consensus regarding the optimal treatment, management of these fractures depends on hospital protocols and surgeon preferences.

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There are several studies in which 2 surgical treatments were compared, mostly hook plates versus locking plates.^{12,26,47,57,68,71,73} Hsu et al,²² with the only clinical controlled trial on Neer type II DCF, found no difference in range of motion and union and complication rates when comparing hook plate with TBW in 30 patients and follow-up of 6 months. In the latest systematic review regarding this subject, Oh et al⁴⁸ confirmed the previously described high nonunion rate after nonoperative treatment. They found no differences in patient-reported outcome measures (PROMs) and cited fewer complications with nonoperative treatment than with all operative treatment options in 425 patients. However, studies comparing all operative techniques and nonoperative treatment in terms of functional outcome and complication rate are rare, and more evidence is needed.

The goal of this systematic review and meta-analysis is to evaluate which surgical technique is optimal and to evaluate nonoperative treatment in managing Neer type II DCF with regard to functional outcome and union, complication, and revision rates.

METHODS

Literature Search and Study Design

A systematic review of the literature was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.³⁸ A clinical librarian (C.d.H.) performed a computer-based search of the literature databases PubMed, Embase, CENTRAL, CINAHL/EBSCO, Web of Science/Clarivate Analytics, and SPORTDiscus/EBSCO for studies from inception to January 27, 2021, which comprised keywords for clavicle or collar bone, fracture, and Neer type II (Appendix Tables A1-A6, available in the online version of this article).

Inclusion and Exclusion Criteria

All retrospective and prospective cohort and case studies were included that assessed patients who underwent nonoperative or operative treatment for a Neer type II DCF. Patients were included if they had fractures <2 weeks old and were without associated injuries, preexisting subacromial pathology, or previous surgery in the ipsilateral shoulder or arm. Articles were included with a minimum sample of 20 patients who were ≥ 18 years of age with a minimum follow-up of 12 months. Articles in Dutch, English, Spanish, French, German, or Arabic were included. Biomechanical and cadaveric studies were excluded. Each study was required to report the following predetermined variables: demographic data, nonoperative and operative treatment, patient-reported functional scores, and complication and union rates.

Outcomes and Definitions

The primary outcome was PROMs at >12 months. If the time of registration was not mentioned, we considered it as being administered at latest follow-up. Secondary outcomes were union, complication, and revision rates. The term nonunion was defined by the authors of the included studies. Delayed union was considered union. Heterotopic ossifications were not considered a complication but sequelae. Breakage, displacement, loss of reduction, and symptomatic hardware were considered hardware failure. *Revision* was defined as a nonelective additional surgery. Elective removal was considered a reoperation but not a revision. When postoperative adequate trauma occurred resulting in new pathology, we did not consider this a complication, nor did we score the required reoperation as revision. Hardware-related symptoms that subsided after elective removal were not defined as a complication.

Data Extraction

After duplicate removal, studies were screened by title and abstract and subsequently full text was reviewed by 2 independent reviewers (S.J.U. and L.J.M.v.E.). A third author was consulted (M.P.J.v.d.B.) if consensus was not reached.

All predetermined variables and data were independently extracted by 2 reviewers (S.J.U. and L.J.M.v.E.) and analyzed using the Review Manager Version 5.3 (Cochrane Collaboration). When a study comprised >1 treatment group, the study arms were analyzed as separate studies. If needed, authors were contacted to provide additional data. If no response was recorded within 4 weeks and after a reminder email, the article was excluded.

Quality Assessment

Quality assessment was independently performed by 2 reviewers (S.J.U. and L.J.M.v.E.) using the Newcastle-Ottawa Scale.⁶⁴ This scale is recommended by the Cochrane Collaboration, and it uses a star rating system in 3 domains: selection, comparability of study groups, and assessment of the outcome of interest. A maximum of 4, 2, and 3 stars can be scored per domain, respectively.

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

Study quality was considered good, fair, and poor when scored with \geq 7, 5 or 6, and \leq 4 stars. Regarding comparability, we used 3 predetermined confounding factors: age (1 star) and smoking status and/or hospital/surgeon volume (another star).

Statistical Analysis

Clinical outcomes are summarized as absolute numbers with frequencies for categorical variables, means with standard deviations for normally distributed continuous variables, and medians with interquartile ranges for nonnormally distributed continuous variables.

A meta-analysis with random effects as a statistical model was performed to compare operative and nonoperative treatments after Neer type II DCF. The weighted mean difference and 95% CIs for continuous variables were calculated. For dichotomous variables, the odds ratio and 95% CIs were calculated. The result was considered nonsignificant when any weighted mean difference interval included zero or when the 95% CI included 1 for continuous and dichotomous variables, respectively. A P value <.05 was considered significant.

Combined PROM Rate

To represent functional outcome per treatment group, a combined PROM rate was calculated of the most frequently used PROMs. It was defined as a percentage from 0 to 100 corresponding to the weighted mean regarding the total score of the PROM, with 100% implying maximum success. For example, an American Shoulder and Elbow Surgeons (ASES) score of 89 corresponded to an 89% combined PROM rate since the scale is from 0 to 100. A University of California, Los Angeles (UCLA), score of 32 corresponded to 91% since the scale is from 0 to 35. Ultimately, a mean of the combined PROM scores was calculated.

RESULTS

Literature Search and Study Design

The search strategy for all databases is outlined in Appendix Tables A1 to A6 (available online). The database search yielded 3095 studies (Figure 1). After duplicate removal and title, abstract, and full-text screening, 59 articles remained, comprising 85 independent study arms and 2284 Neer type II DCFs. The highest level of evidence was 3 in 13 prospective studies, followed by level 4 in 46 retrospective cohort studies. No level 2 randomized controlled trials were available that matched our inclusion criteria.

Quality Assessment

According to the Newcastle-Ottawa Scale, 93% of the studies were of good and fair quality (Table 1). Full quality assessment is shown in Appendix Table A7 (available online).

Operative Treatment

A variety of operative techniques were used, which were divided into 10 treatment groups (Table 2). The alternative plate group comprised distal clavicle plates, locking plates, precontoured locking plates, superior clavicle plate with lateral extension,⁴⁷ and distal radius T plates.⁵⁷ The Ochen et al⁴⁷ study was included in union analysis but excluded in the functional outcome analysis because of missing data. In total, 35 studies were single armed, whereas 24 articles comprised multiple treatment groups.

Specific Shoulder Outcomes

Constant-Murley score (CMS), UCLA shoulder rating scale, ASES shoulder score, and Disabilities of the Arm, Shoulder and Hand (DASH) were used across 59, 18, 13,

 TABLE 1

 Newcastle-Ottawa Scale Quality Groups of the 59 Included Studies

Good Quality	Fair Quality	Poor Quality		
Baunach et al ³	Andersen et al ¹	Das et al ⁸		
Chen et al^5	Dávila et al ⁹	Edwards et al ¹¹		
Chun and Kim ⁷	Fazal et al ¹⁵	Fann et al ¹⁴		
Dedeoğlu et al ¹⁰	Flinkkilä et al ¹⁶	Flinkkilä et al ¹⁷		
Erdle et al ¹²	Haidar et al ¹⁹			
Fan et al ¹³	Hohmann et al ²⁰			
Hsu et al ²¹	Kanchanatawan and Wongthongsalee ²³			
Kraus et al ²⁷	Kapil-Mani et al ²⁴			
Kuner et al ²⁸	Kashii et al ²⁵			
Kwak et al ²⁹	Klein et al ²⁶			
Lanier et al ³⁰	Lee et al^{31}			
Lee et al ³²	$Meda et al^{41}$			
Lee et al ³³	Mirbolook et al ⁴²			
Lee et al ³⁴	Nordqvist et al ⁴⁶			
Leu et al ³⁵	RanaÎletta et al ⁴⁹			
Li et al ³⁷	Renger et al^{50}			
Lopiz et al ³⁹	Rokito et al ⁵³			
Loriaut et al ⁴⁰	Serban^{55}			
Mochizuki et al ⁴³	Seyhan et al ⁵⁶			
Ochen et al ⁴⁷	Teoh et al^{58}			
Robinson et al ⁵¹	Tiren et al ⁵⁹			
Seo et al ⁵⁴	Varyani ⁶¹			
Tan et al ⁵⁷	Wang and Wong ⁶³			
Tsuei et al ⁶⁰	Xie et al ⁶⁷			
Wang et al ⁶²				
Wu et al ⁶⁵				
Xiong et al ⁶⁸				
Xu et al ⁶⁹				
Zhang et al ⁷¹				
Zhang et al ⁷²				
Zhang et al ⁷³				
Total: 31 (52%)	Total: 24 (41%)	Total: 4 (7%)		

and 12 study arms, respectively. Less frequently used PROMs—and therefore not analyzed in this study—were the Subjective Shoulder Value, Oxford Shoulder Score, and QuickDASH (used 7, 6, and 4 times, respectively). Three studies^{15,17,37} used an unusual questionnaire, and 3 studies^{11,30,68} did not use any PROM. The data of 1 study⁷² were not adaptable for analysis owing to division of its population into subgroups. The screw and titanium cable groups (CC fixation) were not evaluated by PROMs in any study.

Combined PROM Rate

The TBW/KW and hook plate groups showed the lowest rates (86% and 89%, respectively). The highest rate (96%) was seen with alternative plates (Table 3).

Constant-Murley Score

The CMS was used for functional meta-analysis as it was the most frequently used PROM among all studies. Analysis was done by comparing hook plate versus locking plate, hook plate versus CC fixation, hook plate versus TBW/KW, and locking plate versus locking plate with additional CC fixation. Hook plates showed lower CMS results when compared with CC fixation (standard mean difference [SMD], -0.77; 95% CI, -1.26 to -0.28; P = .002; $I^2 = 31\%$) in 2 studies involving 112 patients.^{16,21} In addition, the locking plate without additional CC fixation was associated with a lower CMS outcome in 2 studies involving 62 patients^{13,69} (SMD, -0.85; 95% CI, -1.42 to -0.27; P = .004; $I^2 = 13\%$) (Figure 2).

There was no difference in functional outcome between hook plates and locking plates (SMD, -0.62; 95% CI -1.19 to -0.05; P = .03; $I^2 = 72\%$) or TBW/KW (SMD, 0.43; 95% CI -0.23 to 1.09; P = .21; $I^2 = 78\%$).

Other PROMs

UCLA scores were similar among the following groups: PDS banding (CC fixation), hook plate, alternative plate, TBW/KW, and combination of operative techniques/other. The worst DASH scores belonged to the transacromial pin group (2.7; range, 0-8.3) and the "combination of operative techniques/other" group 2.1 (range, 0-15.8). Hook plates achieved the best DASH (10.0; range, 0-29.2). Among the operative techniques, the best ASES result (92) was observed in the "combination of operative techniques/other" group (Table 4).

TABLE 2Patients per Treatment Group

Operative Technique	No. (%)
Coracoclavicular fixation	
Screw	30 (1)
Button device	239 (10)
Polydioxanone suture banding	100 (4)
Titanium cable	29 (1)
Hook plate	857 (38)
Transacromial pins	126 (6)
Alternative plate	292 (13)
Tension band wire/K-wire	86 (4)
Combination of operative techniques/other	466 (20)
Nonoperative	59 (3)
Total	2284 (100)

Union

Neer type II DCF had a union rate of 98% after operative treatment. There was no significant difference in union rate after hook plate as compared with a locking plate, 8,12,47,57,62,71 CC fixation, 5,16,21,68 or TBW/KW^{17,34,35,65} (Table 2). Lower union rates were seen in TBW/KW (92%) and CC fixation by button device (94%) or PDS banding (96%) (Figure 3). The 53 postoperative nonunions were in 38% of symptomatic cases, 36% of asymptomatic cases, and 26% undescribed cases.

Complications

The complication rate per treatment group was as follows: CC fixation by screw fixation, 10%; button device, 12%; PDS banding, 6%; titanium cable, 3%; hook plate, 24%; transacromial pins, 37%; alternative plate, 10%; TBW/ KW, 80%; and combination of operative techniques/other, 18% (Table 5). Of all complications, 40% were hardware related. In the TBW/KW and transacromial pin groups, hardware failure was present in 62% and 26% of the cases, respectively. Infection and wound problems were most often reported in the TBW/KW group (9%). Osteolysis was found only in operative treatment using plate fixation. The second highest acromicclavicular (AC) arthrosis rate (9%) was seen after transacromial pin fixation.

Revision Rate

Reoperations were performed in all operative treatment groups except in patients treated with CC fixation by screws. The lowest revision rates were found in CC fixation by PDS banding and titanium cable (2% and 3%, respectively). A reoperation rate of 100% was observed in the hook plate group because all plates were removed electively. Rate of additional revision attributed to a complication was 4%. Fixation by TBW/KW had the highest revision rate (30%). A combination of surgical techniques or other treatment showed a revision rate of 12%.

TABLE 3	
Combined PROM Rate per Treatment Gr	oup

	PRO	OMs
Foracoclavicular fixation Screw Button device Polydioxanone suture banding Titanium cable Took plate ransacromial pins Iternative plate ension band wire/K-wire	%	$\mathrm{No.}^{b}$
Coracoclavicular fixation		
Screw	Missing	Missing
Button device	92.8	302
Polydioxanone suture banding	92.8	151
Titanium cable	Missing	Missing
Hook plate	88.9	957
Transacromial pins	91.9	236
Alternative plate	96.4	406
Tension band wire/K-wire	86.0	86
Combination of operative treatments/other	92.6	529
Nonoperative	90.4	48

^aPROM, patient-reported outcome measure.

^bTotal filled-out questionnaires within the treatment group.

Nonoperative Treatment

Among 3 studies including 59 patients, a nonunion rate of 31% was reported, of which 50% were symptomatic, 28% asymptomatic, and 22% not described.^{11,46,53} The union rate was thus significantly lower compared with operative treatment^{11,53} (SMD, 0.05; 95% CI, 0.01-0.37; P = .004; $I^2 = 0\%$). The overall complication rate was 51%. Symptomatic nonunion was the most frequent complication (15%), followed by AC arthrosis (12%) and impingement syndrome (8%). Five cases (8%) still required surgery because of 1 symptomatic nonunion, 1 excessive callus formation, and 3 unmentioned reasons.

The study by Rokito et al,⁵³ including 16 patients with a mean age of 47.1 years, was the only nonoperative study group with PROMs. During a follow-up of 53.5 months (range, 30-90), the authors reported a CMS of 92.5, UCLA of 31.1, and ASES of 89.9, which did not differ significantly when compared with operative treatment (P =.13, P = .67, P = .77, respectively). Mean PROMs for the patients with a nonunion after nonoperative treatment were as follows: CMS, 94.8; UCLA, 31.1; and ASES, 89.9 (P = .46). Also, the presence of nonunion did not affect strength.

In the study of Nordqvist et al,⁴⁶ 17 of 23 patients remained asymptomatic: they had an average age of 35.1 years (range, 11-83) and a follow-up of 36 months (range, 11-264); none were severely disabled; and all returned to previous occupations. Edwards et al,¹¹ whose study included 20 patients with a mean age of 32 years (range, 11-83), reported marginal information about functional results during a follow-up of 36 months.

DISCUSSION

This systematic review and meta-analysis aimed to evaluate the functional outcomes and union, complication, and revision rates of operative and nonoperative treatment for Neer type II DCF and, furthermore, to determine the

-0.77 [-1.26, -0.28]

	Hook	plate	CC fix	ation	
Study or Subgroup	Mean	Total	Mean	Total	Weight
Flinkkila (2014)	89	19	93	21	43.6%
Hsu et al	87	49	95	23	56.4%
Total (95% CI)		68		44	100.0%
Hotorogonoity Tour	0.04.06	8-1.46	df = 1	(D = 0 '	221-18-244

Heterogeneity: Tau² = 0.04; Chi² = 1.46, df = 1 (P = 0.23); i² = 31% Test for overall effect: Z = 3.09 (P = 0.002)

2a. Hookplate versus CC fixation





Std. Mean Difference IV, Random, 95% CI

Hook plate CC fixation

2b. Locking plate versus locking plate with additional CC fixation

	Hook p	olate	plate		
Study or Subgroup	Mean	Total	Mean 1	fotal	Weight
Das et al.	82	17	87.6	15	20.4%
Erdle et al.	88.7	19	92.2	13	23.0%
Wang, Liang et al.	88.91	33	90	31	28.3%
Zhang et al.	93.3	30	95.5	36	28.4%
Total (95% CI)		99		95	100.0%
Heterogeneity: Tau ² =	0.24; Chi ^a	= 10.65	5, df = 3 (P	= 0.0	1); I ² = 72%
Test for overall effect:	Z = 2.11 (F	= 0.03)		

2c. Hookplate versus locking plate*

	Hook p	olate	TBW/	w	
Study or Subgroup	Mean	Total	Mean	Total	Weight
Lee Y.S.	90	32	88	20	32.7%
Leu et al	85.7	25	86.94	20	32.0%
Wu et al (2011)	90.43	92	85.63	24	35.3%
Total (95% CI)		149		64	100.0%
Heterogeneity: Tau ² :	= 0.27; Chi ²	= 9.10	0, df = 2 ((P = 0.0)	1); I ² = 78%
Test for overall effect	Z = 1.27 (P = 0.2	(1)		

2d. Hookplate versus TBW/KW





* The CMS of Wang, Liang et al. was measured at 6 months follow-up.

Figure 2. Forest plots of Constant-Murley Score at latest follow-up. CC, coracoclavicular; CMS, Constant-Murley Score; IV, inverse variance; TBW/KW, tension band wire/K-wire.

optimal operative treatment. The most important findings of this study were that CC fixation was superior to hook plates and that locking plates showed significantly better function when combined with CC fixation. Hook plates were the most frequently researched operative treatment, whereby it could be wrongly interpreted as the gold standard. Despite providing good union, hook plates scored lowest on functional outcomes, and 1 of 5

		CMS		UCLA			
	12 mo	Last Follow-up	Not Reported	12 mo	Last Follow-up	Not Reported	
Coracoclavicular fixation							
Screw							
Button device		$87.0^{b} (62-100)$	93^c				
Polydioxanone suture banding		93.3 (71-100)	88.1^{c}		33.9^d (30-35)	30.7^c	
Titanium cable							
Hook plate		89.6 (64-100)	86.6 (64-100)		31.6^d (21-35)		
Transacromial pins		98.8 (85-100)	94.3 (85-100)		31.4 (20-35)	29.9(29-35)	
Alternative plate	94.5 (82-98)	93.4 (80-99)	89.1 (81-98)	32.3(26-34)	32.5(27-35)	27.1^c	
Tension band wire/K-wire		85.63^{c}	86.2 (68-100)				
Combination of operative techniques/other	95.1^c	91.7 (95-100)	90.3 (64-99)		33.8 (13-35)	29.4^c	
Nonoperative			92.5^c			31.1^c	
		DASH		ASES			
	12 mo	Last Follow-up	Not Reported	12 mo	Last Follow-up	Not Reported	
Coracoclavicular fixation							
Screw							
Button device	2.4^c	2.2(0-8.8)	6^c		79.9 (66.9-88.3)		
Polydioxanone suture banding						82.9^c	
Titanium cable							
Hook plate		10.04 (0-23.3)	5.9(0-29.2)		84.3^d (66.7-100)		
Transacromial pins			2.7(0-8.3)				
Alternative plate			4.1^c				
Tension band wire/K-wire							
Combination of operative techniques/other	3.5 (1-16)	2.1(0-15.8)	2.82^c	92.3^c	86.9 (33.3-100)		
Nonoperative						89.9^{c}	

TABLE 4Weighted Mean (Range) of Patient-Reported Outcome Measures per Treatment Group a

^aNot Reported indicates the studies did not report when the questionnaires were filled in. ASES, American Shoulder and Elbow Surgeons; CMS, Constant-Murley Score; DASH, Disabilities of the Arm, Shoulder and Hand; UCLA, University of California, Los Angeles.

^bPatients with a nonunion were not included in the mean CMS.

^{*c*}Range is missing.

^{*d*}At 2 years of follow-up.

patients experienced a complication. Moreover, the discomfort might still be underestimated because we decided not to register symptomatic hardware if complaints subsided after elective removal. Additionally, every patient required a second operation and 5% had to undergo a third, with the disadvantage of corresponding costs and risks.

Of all the techniques for CC fixation, the majority are evaluated in small studies. Screw fixation seems promising in terms of good union and few complications. However, some screws have to be removed. Alternative plates seem to be a good alternative operative treatment, with good functional outcomes, a high union rate, and average complication and revision rates. Fixation by TBW/KW or transacromial pins showed the lowest functional outcome with high complication and revision rates.

In most studies, a combination of surgical techniques was proposed. This highlights the challenging aspects when managing DCF, because of its small lateral part and the strong forces of the ligaments and muscles that surround it. Unsurprisingly, surgeons hypothesized that a combination of vertical and horizontal fixation would be superior. Our meta-analysis confirmed this theory. Nevertheless, the combination group showed 10% hardware failure, and complication and revision rates were average to high when compared with other groups.

Nonoperative treatment showed similar functional outcome when compared with any operative treatment. Although we confirmed the high nonunion rate, only half were symptomatic, and just 8% required eventual surgery. While AC osteoarthritis may be an important problem in this group, it could not be distinguished if this was symptomatic.

The biggest limit when evaluating nonoperative treatment is that available literature is scarce; only 59 patients could be included in this study.^{11,46,53} Interestingly, Robinson and Cairns,⁵² who were excluded from this study because of missing data, found borderline significant outcomes favoring nonoperative treatment in 101 middleaged and elderly patients as compared with operative treatment.

Three meta-analyses have been published regarding this topic. First, Li et al³⁶ compared hook plates and distal clavicle plates in 306 patients. They showed that distal clavicle locking plates had better CMS results at 3 and 6 months after surgery. No significant differences were found concerning union rate or impingement syndrome.

	Hook p	late	Locking			
Study or Subgroup	Events	Total	Events	Total	Weight	
Das et al.	17	17	15	15		
Erdle et al.	18	19	13	13	24.2%	
Ochen et al	chen et al 18 19 47 48				32.6%	
Tan et al.	23	23	19	19		
Wang, Liang et al.	33	33	31	31		
Zhang et al.	28	30	35	36	43.2%	
Total (95% CI)		141		162	100.0%	
Total events	137		160			
Heterogeneity: Tau ² = 0	.00; Chi ² = 1	0.01, df=	= 2 (P = 1.0	0); I ² = 0%	,	
Test for overall effect: Z	= 1.09 (P =	0.27)				

Hook plate

28

18

45

25

116 Heterogeneity: Tau² = 0.00; Chi² = 0.27, df = 2 (P = 0.87); l² = 0%

Total

28

19

49

25

121

Events

CC fixation

40

20

20

27

107

Events Total

40

21

23

28

112

3a. Hookplate versus locking plate*

Study or Subgroup

Chen et al

Hsu et al

Xiong et al.

Total (95% CI)

Total events

Flinkkila (2014)



0.005

0.1

Odds Ratio M-H, Random, 95% CI

Test for overall effect: Z = 0.73 (P = 0.47) 3b. Hookplate versus CC fixation*

	Hook p	late	TBW/	w						
Study or Subgroup	Events	Total	Events	Total	Weight					
Flinkkila (2002)	15	17	20	22	44.7%					
Lee Y.S.	32	32	19	20	18.4%					
Leu et al	24	25	16	20	37.0%					
Wu et al (2011)	92	92	24	24						
Total (95% CI)		166		86	100.0%					
Total events	163		79							
Heterogeneity: Tau ² = 0.02; Chi ² = 2.03, df = 2 (P = 0.36); I ² = 2%										
Test for overall effect: Z =	Test for overall effect: Z = 1.16 (P = 0.25)									



Hook plate CC fixation

10

200

3c. Hookplate versus TBW/KW*



3d. Non operative treatment versus operative treatment

* For the studies of Das et al, Tan et al, Wang, Liang et al, Chen et al. and Wu et al. the odds ratio was not estimable.

Figure 3. Forest plots of union analysis. CC, coracoclavicular; M-H, Mantel-Haenszel; TBW/KW, tension band wire/K-wire.

Asadollahi and Bucknill² reported no significant difference in functional outcome and union rate among hook plate, CC stabilization, and locking plate in a systematic review comprising 634 patients. However, their most important limitation was the inclusion of the study of Yan et al,⁷⁰ which is biased because it primarily excluded patients with nonunions. Boonard et al⁴ compared the functional outcome of 5 operative methods (CC fixation,

						C	Complicat	ion Rate, %	6		
			N	onuni	on						
Treatment Group	No. of Patients	Union Rate, %	s	Α	NR	IS	HWF	INF/WP	Osteolysis	AC OA	Revision
Coracoclavicular fixation											
Screw	30	100					7	3			
Button device	239	94	3	2	<1		2	4		<1	5
Polydioxanone suture banding	100	96		3	<1			2			2
Titanium cable	29	100					3				3
Hook plate	857	98	<1	<1	<1	4	5	1	7	5	4
Transacromial pins	126	98			2		26	<1		9	9
Alternative plate	292	99			<1		4	2	1	1	10
Tension band wire/K-wire	86	92	3		5	1	62	9			30
Combination of operative techniques/other	466	99	<1	<1	1	1	11	3	<1	<1	12
Nonoperative	59	69	15	8	7	8				12	8
Total	2284	97	1	1	<1	2	9	2	3	3	8

TABLE 5 Union and Complication Rates^a

^{*a*}A, asymptomatic; AC, acromioclavicular joint; HWF, hardware failure; INF, infection; IS, impingement syndrome; NR, not reported; OA, osteoarthritis; S, symptomatic; WP, wound problems.

hook plate, locking plate, TBW, and transacromial KW fixation) in 547 patients and showed that CC fixation and locking plates resulted in higher CMS and UCLA scores when compared with the other surgical methods. Locking plates had the lowest complication rate and transacromial KW, the highest. Their limitations were exclusion of nonoperative treatment and nonunion rate, and they likewise included Yan et al.

Only 1 trial was performed comprising patients who randomly received TBW or hook plates (n = 65).¹⁹ Although better functional outcome was seen after TBW 3 months postoperatively, the difference faded at 6 months. This study was excluded in this review because follow-up was <12 months.

These previous reviews required an update because they were outdated and comprised small sample sizes. Our extended literature search uncovered novel studies.^{26,35,68} To the best of our knowledge, this is the largest systematic review comprising a variety of operative techniques and displaying patient-reported and clinical outcomes during a follow-up of at least 12 months.

Nonetheless, there are various points of consideration when interpreting the conclusions of this review. Not all studies described all relevant information, such as symptoms of a nonunion, reasons for revision, the exact time after surgery of PROM fulfillment, or complications. Explicitly, the studies did not have identical predetermined definitions of reported complications, and long-term problems could have been missed because of limited follow-up, especially concerning cases of AC osteoarthrosis. Also, it cannot be excluded that these cases were not preexistent.

Another limitation was that the results regarded many small series with different approaches (open or arthroscopic, locking vs nonlocking screws), which were not corrected for independent risk factors. Furthermore, this review did not differentiate age, which could theoretically be an interesting factor for the indication of nonoperative treatment because elderly patients have lower functional demands. Kashii et al²⁵ divided their population into age groups of 21 to 40, 41 to 60, and 61 to 74 years and found best functional outcomes in the youngest group and evidently lower functional outcomes in the eldest group when treated with a hook plate (average Japanese Orthopaedic Association scores of 99.4, 98.6, and 95.7, respectively).

Another possible confounding factor was that in all except 1 study, the time between the occurrence of the fracture and the surgical intervention was not evaluated. Furuhata et al¹⁸ divided their patients into treatment groups according to time to surgery. They observed no significant differences between the early and delayed surgery groups.

Finally, in the management of DCF, the lateral acromial angle should be considered. This is defined as the incline angle between the superior and inferior surface of the distal clavicle and acromion on the coronal plane. Previous studies showed a correlation between a large lateral acromial angle (>40°) and postoperative pain and impingement symptoms.^{6,66}

CONCLUSION

On the basis of this study reviewing 2284 patients, we recommend CC fixation as first choice when managing Neer type II DCF. Plate fixation with supplemental CC fixation can be a good alternative. According to our results, the use of TBW/KW and hook plates is discouraged because of their high complication rates.

Nonoperatively treated patients showed good functional outcomes despite the 31% nonunion rate. However, because of the small sample size, no hard statements can be made and further research is needed. Although it is difficult to collect study data because of the rarity of Neer type II DCF, a randomized controlled trial with an adequate sample size and a minimal follow-up of 12 months would be imperative to determine the best technique. Finally, age should be investigated as a prognostic factor for functional outcomes in future long-term nonoperative studies.

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