SCIENTIFIC ARTICLE

Dorsal Bridge Plate for Distal Radius Fractures: A Systematic Review

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Purpose This study presents patient demographics, injury characteristics, outcomes, and complications associated with dorsal bridge plating (DBP) in the treatment of distal radius fractures.

Methods A literature search performed according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines identified 206 articles, 12 of which met inclusion criteria, accounting for 310 patients. Included articles contained the results of DBP for treatment of distal radius fractures with reported outcomes between 1988 and 2018. Data were pooled and analyzed focusing on patient demographics, as well as 3 primary outcomes of complications, range of motion (ROM), and Disabilities of the Arm, Shoulder, and Hand (DASH) and *Quick*DASH scores.

Results Average age was 55 years, median follow-up was 24 months, and the most common use was in comminuted (92%) intra-articular (92%) distal radius fracture caused by fall (58%), or motor vehicle collision or motorcycle collision (27%). A minority of patients had open fractures (16%) and most were cases of polytrauma (65%). Median time from placement to DBP removal was 17 weeks (mean, 119 days). At final follow-up, mean wrist ROM was 45° flexion, 50° extension, 75° pronation, and 73° supination. Mean DASH score was 26.1, and mean *Quick*DASH score was 19.8. The overall rate for any complication was 13%; the most common was hardware failure (3%) followed by symptomatic malunion or nonunion (3%), and persistent pain after hardware removal (2%).

Conclusions Dorsal bridge plating was found to be used most commonly in intra-articular, comminuted distal radius fractures with overall functional wrist ROM, moderate patient-reported disability, and a 13% complication rate at follow-up. *(J Hand Surg Am. 2021;46(7):627.e1-e8. Copyright © 2021 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words Distal radius fracture, distraction plate, dorsal bridge plate, internal radiocarpal distraction plate, spanning bridge plate.

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DISTAL RADIUS FRACTURES often occur as a fragility-type fracture or as the result of high-energy trauma, accounting for 17% to 18% of all adult fractures.[1–7] Historically, distal radius fractures were primarily treated with the placement of an orthosis or casting or limited percutaneous fixation.[8] Over the past 2 decades, volar locked plating (VLP) has emerged as a treatment option for distal radius fractures, particularly among hand surgeons.[9–12] However, in high-energy, severely comminuted, and unstable distal radius fracture patterns, a periarticular volar locked plate may not be able to stabilize the distal radius adequately.[13] Initially, distraction methods using external fixation were explored for such fracture patterns. However, this method had a high complication rate including hand stiffness, pin site infections, and malreduction.[14–16] To reduce the incidence of pin site infections and the encumbrance of an external fixator in daily activities, a dorsal bridge plate (DBP) technique was developed to span the carpus, allowing weight-bearing through the injured extremity with theoretically fewer complications compared with external fixation.[17] However, there is concern that the DBP technique may result in stiffness necessitating additional surgery.[18] The purpose of this analysis was to review patient demographics, injury characteristics, outcomes, and complications associated with DBP for the treatment of distal radius fractures.

MATERIALS AND METHODS

This analysis is reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[19]

Search strategy and selection of studies

We performed a systematic review for all articles published on the treatment of "distal radius fractures" treated with "dorsal bridge plate" or "distraction plating." PubMed, Google Scholar, and EBSCO were queried from 1988 to 2018 with combinations of search terms: "bridge plate," "distraction plate," "dorsal bridge plate," "distal radius," "spanning plate," and "internal radiocarpal plate." The abstracts generated by the search were individually assessed for relevance by 2 of the authors. Full articles were reviewed independently according to the inclusion and exclusion criteria. We extracted homogeneous data from studies that met inclusion and exclusion criteria and generated frequency-weighted means. A systematic review was performed after completion of data collection.

Eligibility

This study included articles that (1) were published in a peer-reviewed, English language North American or European journal, (2) reviewed results of treatment with DBP for distal radius fractures, and (3) reported at least one outcome such as complications, range of motion (ROM), strength, or functional outcome score. Studies were excluded if they (1) were a technique description, therapy article, biomechanical analysis, letter to the editor, or review; (2) analyzed treatment of distal radius fractures other than by DBP; (3) were not written in English; (4) reviewed a case series subsequently included in another published case series[19]; (5) involved treatment of a perilunate dislocation, ligamentous injury, or wrist arthrodesis; (6) were published in a non-American or non-European journal; or (7) were published more than 30 years ago.

Data extraction

We extracted and analyzed the study design, demographic variables, and all relevant surgical and functional outcomes as well as complications.

Primary outcome measures were complications, ROM at final follow-up, and *Quick*—Disabilities of the Arm, Shoulder, and Hand (*Quick*DASH) scores. The authors independently extracted and compiled the data.

Assessment of methodological quality and data collection

The Grading of Recommendations Assessment, Development, and Evaluation Working Group criteria are an assessment template used to evaluate the quality of methods used in published studies.[20] Using this template, the 2 primary authors independently assessed the quality of the selected studies. Disagreement concerning study quality was moderated by the senior author.

Data pooling across studies and data analysis

Demographic variables, surgical variables, and outcomes were pooled, and weighted averages were obtained. Weighted averages were calculated based on the number of patients in a given study when the authors reported sample means, rather than individual values for each patient. Heterogeneity in demographic and surgical variables among the included studies were assessed using Cochran's Q and I^2 statistics. The nature of the case series reported in this study led to Grading of Recommendations Assessment, Development, and Evaluation Working Group level of evidence considered low quality, which means that there is likely some degree of publication

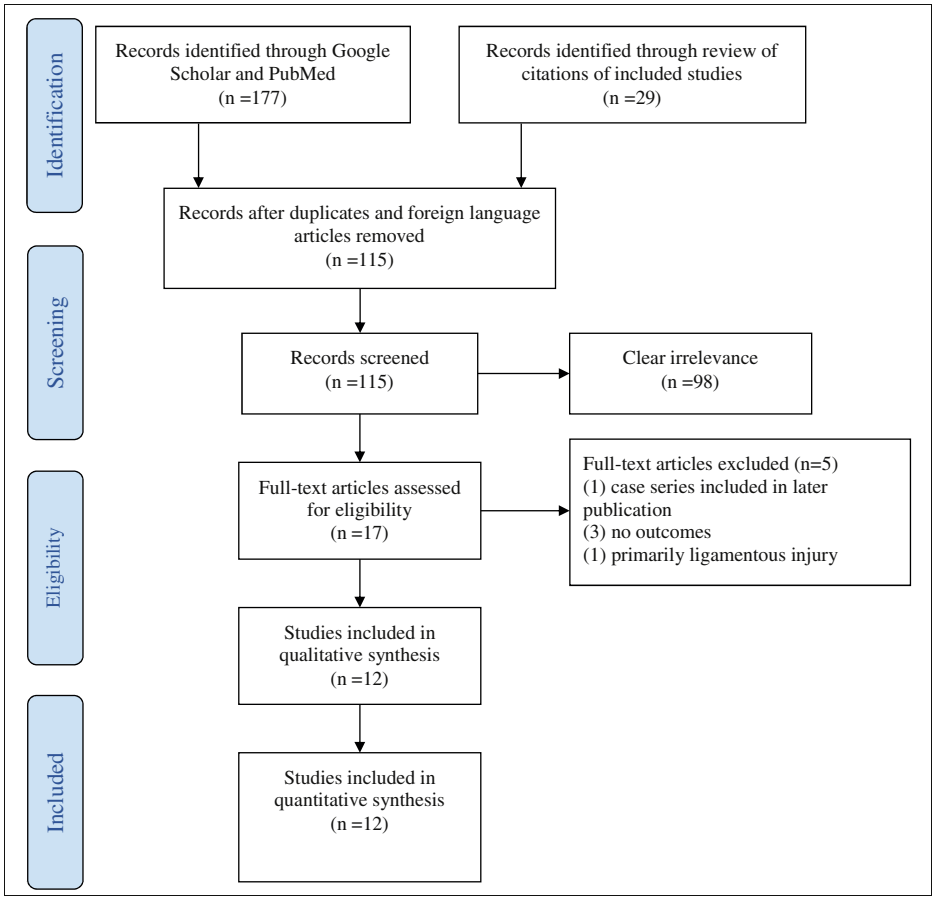

FIGURE 1: Identification of articles for systematic review of DBP for distal radius fractures.

bias and outcome reporting bias particularly given the retrospective nature of the included studies. There were no sources of external funding. Outcomes were compiled and compared with VLP analyses.

RESULTS

The search resulted in 206 potentially eligible studies, 12 of which met inclusion and exclusion criteria accounting for 310 patients (Fig. 1) Average age upon presentation was 55 years with a median follow-up of 24 months (range, 6−48 months). The most common type of distal radius fracture treated with a DBP were comminuted (92%) and intra-articular (92%). These fractures occurred most commonly after a low-energy fall (58%) or a motor vehicle collision or motorcycle collision (27%) (Table 1). Sixteen percent of patients had open fractures. Most distal radius fractures treated with DBP were seen in polytrauma patients (65%). Mean time from DBP placement to removal was 119 days (range, 73−183 days) (Table 2). Cochran's Q and I^2 statistics demonstrated substantial heterogeneity among the demographic variables of sex, dominant limb affected, articular fracture, fracture comminution, open fracture, polytrauma, days to hardware removal, duration of follow-up, and mechanism of injury (I^2, 73%; $P < .05$). *Post hoc* pairwise Cochran's Q analyses demonstrated that variable inclusion of polytrauma, open and comminuted fractures, and disparate follow-up were the primary contributors of heterogeneity (I^2, 56%; $P = .061$).

At final follow-up after hardware removal, mean wrist ROM was 45° flexion (range, 36° to 57°), 50° extension (range, 40° to 65°), 75° pronation (range, 65° to 80°), and 73° supination (range, 68° to 77°) . Distal radius radiographic outcomes at final follow-up demonstrated an overall volar tilt of 5° (range, 4° to 8°), positive ulnar variance of 0.4 mm (range, −0.3 to 1.2 mm), and radial inclination of 19° (range, 18° to 20°). Mean DASH score was 26.1 (range, 11.5−32) and mean *Quick*DASH score was 19.8 (range, 16−23) at final follow-up (Table 3). Cochran's Q and I^2 statistics demonstrated substantial heterogeneity among the reported outcome variables of DASH, *Quick*DASH, volar tilt, ulnar variance, radial inclination, ROM, and grip strength (I^2, 70%; $P < .05$).

TABLE 1. Mechanisms of Injury*

Mechanisms of Injury	Articles Reported, n	n	Count	%	Total Mechanism % (n = 252)
Any mechanism	9	252	248	98	
High-energy fall	2	44	19	43	7
Low-energy fall	9	251	146	58	58
Motor vehicle or motorcycle collision	7	239	69	29	27
Other mechanism†	3	185	15	8	6

*Reported as a percentage of patients in articles that reported that mechanism as well as a percentage of all patients with reported mechanisms.
†Other mechanisms include pedestrian, direct blow, crush, gunshot wound, and table saw.

TABLE 2. Demographic Data

Demographics	Articles Reported, n	N	Count	%	Weighted Mean (range)	Median (range)
Age, y	12	310			55	
Male	11	299	173	58		
Dominant hand injured	6	82	43	54		
Articular fracture	9	160	147	92		
Comminuted fracture	8	152	140	92		
Open fracture	7	214	36	160		
Polytrauma	6	71	46	65		
Days to plate removal	11	292			128 (73–183)	119 (73–183)
Follow-up, mo	7	226			15 (6–48)	24 (6–48)

TABLE 3. Functional Outcomes and ROM at Final Follow-Up

Functional Outcomes	Articles Reported, n	n	Weighted Mean (range)
DASH	4	83	26 (11–32)
QuickDASH	2	39	20 (16–23)
Volar tilt (°)	5	119	5 (4–8)
Ulnar variance, mm	6	140	1 (−1 to 1)
Radial inclination (°)	5	118	19 (18–20)
Flexion (°)	8	148	45 (36–57)
Extension (°)	8	148	50 (40–65)
Pronation (°)	8	148	75 (65–80)
Supination (°)	8	148	73 (68-77)
Grip strength (% of uninjured side)	4	81	68 (55–84)

The overall rate for any complication related to DBP was 13%; the most common were hardware failure (3%), symptomatic malunion or nonunion (3%), and persistent pain (2%). Although, extensor tendon lag less than 10° and persistent pain appeared to have the highest weighted averages (12% and 9%, respectively), they were not the most frequently encountered complication in the entire cohort (Table 4). Cochran's Q and I^2 statistics demonstrated considerable heterogeneity among the reported complications of hardware failure, deep infection or wound-healing problems requiring surgery, superficial or wound-healing problems requiring additional follow-up without surgery, articular stepoff,

TABLE 4. Included Studies for Systematic Review.

Article (First Author, Year)	n	Any Complication* (%)	Hardware Failure (%)	Deep Infection or Wound Healing Requiring Surgery (%)	Superficial Infection or Wound Healing (%)	Articular Stepoff >2 mm, Nonunion, or Symptomatic Malunion (%)	Extensor Tendon Rupture (%)	Extensor Tendon Lag <10° (%)	Pain † (%)	Extensor Tendon Tenolysis With Plate Removal (%)
Hanel, 2010[18]	130	15 (12)	5 (4)	3 (2)	2 (2)	4 (3)	1 (1)	NR	NR	2 (2)
Tinsley, 2018[39]	11	2 (18)	2 (18)	0	0	0	0	NR	NR	0
Richard, 2012[13]	33	3 (9)	0	1 (3)	0	0	0	NR	2 (6)	1 (3)
Lauder, 2015[29]	18	2 (11)	0	0	0	0	0	NR	2 (11)	0
Mithani, 2014[30]	8	1 (13)	0	0	0	0	0	NR	1 (13)	0
Bouvet, 2017[26]	21	4 (19)	0	0	1 (5)	3 (14)	0	NR	NR	0
Huish, 2018[31]	19	1 (5)	0	0	0	1 (5)	0	NR	NR	2 (11)
Dodds, 2013[33]	25	3 (12)	3 (12)	0	0	0	0	NR	NR	19 (76)
Ruch, 2005[27]	22	6 (27)	0	3 (14)	0	0	0	3 (14)	NR	0
Jain, 2016[28]	20	3 (15)	0	0	0	0	0	2 (10)	1 (5)	0
Vakhshori 2018[40]	2	1 (50)	0	0	0	0	0	NR	1 (50)	0
Burke, 1998[17]	1	0	0	0	0	0	0	NR	NR	0
Total (weighted average %)	310	41 (13)	10 (3)	7 (2)	3 (1)	8 (3)	1 (1)	5 (12)	7 (9)	24 (8)

*Any complication excluding concomitant extensor tendon tenolysis performed at the time of plate removal.
†Pain included neuropathic pain, neuritis, complex regional pain syndrome, and chronic pain requiring arthrodesis.

symptomatic malunion or nonunion, extensor tendon rupture, extensor tendon lag, and pain (I^2, 88%; $P < .05$). Extensor tendon lag and pain were the only complications that were inconsistently reported.

DISCUSSION

This analysis reports on the patient demographics, injury characteristics, outcomes, and complications associated with DBP in the treatment of distal radius fractures. The outcomes of the included studies demonstrate that DBP is a technique associated with a functional ROM after plate removal and a 13% complication rate at a median of 24 months, a relatively short follow-up.

One of the main theoretical concerns regarding DBP is that prolonged immobilization of the carpus may lead to stiffness and possible loss of ROM resulting in functional deficits after implant removal. However, although the plates were generally removed at an average of 17 weeks (119 days), patients had a wrist flexion-extension arc of 95° (45° flexion and 50° extension), which exceeded the functional range for most daily living tasks.[21–23] One systematic review of distal radius fractures treated with VLP noted 9 studies with aggregate mean ranges of 54° (±9°) of wrist flexion and 56° (±8°) of wrist extension at a follow-up of 13 months.[24] This demonstrates that treatment of distal radius fractures with DBP compared with VLP does not demonstrate differences in arcs of motion that are clinically relevant.

As demonstrated in this review, the outcomes of DBP are generally acceptable, with a mean DASH score of 26.1 (n = 83) and mean *Quick*DASH score of 19.8 (n = 39). Schmelzer-Schmied et al[25] reported on a series of 45 patients treated with other techniques with relatively favorable functional scores. Mean DASH score was 7 (SD, 5.1) for locked plate, 14 (SD, 6.4) for nonlocked plate, and 20 (SD, 11.3) for external fixation. However, that study exclusively treated AO C1−C2 distal radius fractures, whereas most fractures included in the current review were the more complex C3 fracture types, which are associated with inferior functional outcomes.[26] There are no controlled studies that determine which of these treatment options is superior.

Immediate digit ROM after initial DBP application and a regimen focusing on wrist ROM after plate removal are advocated by a number of authors.[13,17,18,27–31] It is recommended that load-bearing through the forearm and elbow should be allowed with a platform crutch when the patient is physiologically stable, and that lifting restrictions vary between 2 and 5 kg to avoid the possibility of fracture through the site of plate fixation, screw pull-out, and loss of fracture reduction.[13,18,27,28] Given the high rate of hardware failure in DBP (3%), it is important to maintain some form of restricted weight-bearing. Most patients achieved maximal motion at an average of 3 months after plate removal,[13] and all patients in one of the largest included cohorts gained functional ROM within a year of plate removal.[32] One study investigated the duration of DBP fixation and return of ROM after plate removal; the authors concluded that there was limited evidence to suggest that prolonged fixation resulted in notable loss of motion.[27] During the postoperative period, most authors suggest periodic radiographic assessments at variable intervals to assess for radiographic signs of healing.[33] Bouvet et al[26] encouraged postoperative computed tomography scans of the wrist to assess the articular reduction, and thereafter in 3-month intervals to verify consolidation.

Although DBP provides reliable fixation for difficult fractures and patients often achieve a ROM that meets the functional threshold, there is a 13% complication rate, which is comparable to the rates seen in VLP.[34–36] The overall infection rate, including superficial and deep infections, was 3% for DBP compared with an infection rate of 3% in a VLP cohort[37] and a 21% rate of superficial infection in fractures treated with external fixation.[38] The rate of extensor tendon ruptures is hypothesized to be higher in DBP given the dorsal position of the fixation; however, there was only a less than 1% rate of extensor tendon ruptures in DBP compared with 2% seen in a systematic review of patients treated with VLP.[34] Furthermore, there was a low rate of other complications including pain, malunion or nonunion, and the need for tenolysis. The most common complication was hardware failure (3%) which may be anticipated after fracture healing and is an indication for hardware removal.[18,33,39] A systematic review looking at complications of VLP found a 7% plate removal rate, most commonly owing to technical error and aberrant screw placement,[34] whereas another systematic review found only less than a 1% rate of plate fracture.[35]

The primary limitation of this systematic review was the poor methodologic quality of the studies. Although we enumerate all complications reported in the included studies, there is an inherent risk in retrospective studies of underreporting complications, which may have decreased the pooled incidence of complications. In addition to the small number of patients included in each study, the substantial heterogeneity among the

demographic variables limits generalizability of the findings and was attributed to the variable patient samples, fracture morphologies, mechanisms of injury, and inclusion of polytrauma patients and open fractures. Furthermore, there was substantial heterogeneity in the reported outcomes in function scores, radiographic parameters, ROM, and grip strength. Finally, complications were reported in all studies, except for inclusion of extensor tendon lag and pain. This increased overall heterogeneity to a considerable level of I^2 of 88% ($P < .05$), which may represent publication and outcome reporting bias. Notably, limited duration of follow-up did not allow for reporting of posttraumatic osteoarthritis as an outcome. Despite the study's limitations, this analysis is the review of DBP uses, outcomes, and complications. We found DBP to be used most commonly in intra-articular, comminuted distal radius fractures with overall functional wrist ROM, moderate patient-reported disability, and a 13% complication rate at follow-up. Longer follow-up and controlled trials comparing DBP with other fixation methods are required to determine the relative incidences of important long-term sequelae of like posttraumatic osteoarthritis.

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