Dorsal Bridge Plating versus External Fixation for Distal Radius Fractures

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Abstract

Background External fixation and dorsal bridge plating are wrist spanning fixation options for distal radius fractures; however, their comparative effectiveness is not well understood. A meta-analysis was conducted to compare the clinical outcomes between these two techniques.

Materials and Methods A PubMed database query of all distal radius fracture cases managed with spanning external fixation or dorsal bridge plating was performed. A total of 28 articles met inclusion criteria, yielding 895 patients for data extraction and comparative analysis.

Results Dorsal bridge plating demonstrated lower rates of infection (2 vs. 10%, $p = 0.05$) and complex regional pain syndrome (1 vs. 4%, $p = 0.04$) but higher rates of hardware failure (4 vs. 1%, $p = 0.026$). Bridge plating also demonstrated higher rates of excellent/good ratings under the Gartland and Werley outcome score (91 vs. 83%, $p = 0.016$). There was no significant difference in DASH (Disability of the Arm, Shoulder, and Wrist) scores, radiographic parameters, or unplanned reoperations between the two spanning fixation options.

Conclusion Bridge plating and external fixation both appear to be comparable for spanning fixation constructs for distal radius fractures, but with bridge plating having a potentially lower complication profile.

Keywords
- bridge plate
- external fixation
- distal radius fracture
- fixation
- meta-analysis

Distal radius fractures are the most common upper extremity fracture, representing up to 16% of all fractures seen in the emergency department.[1–3] The surgical indications for distal radius fractures generally include displaced or unstable fracture patterns. Several fracture fixation constructs are available, with external fixation ("ExFix") being a common and proven technique.[4] The technique involves a closed reduction, or limited open reduction, with ligamentotaxis and application of an ExFix frame to the radius proximally and the index metacarpal distally thereby spanning the fracture and wrist joint (►**Fig. 1A** and **B**). More recently, dorsal bridge plating has been introduced as an alternative to ExFix.[5,6]

The dorsal bridge plate ("bridge plate") technique was originally introduced in 1998, with the goal to manage fractures of the distal radius with extensive articular comminution, and/or for fractures with metadiaphyseal extension.[5] The technique involves a closed or limited open fracture reduction, and insertion of a long-straight dorsal bridge plate under the second or fourth dorsal compartments of the wrist with fixation to the dorsal radial shaft proximally and the index or middle metacarpal shaft distally with multiple screws (►**Fig. 2A** and **B**). Conceptually, it was considered as an "internal ExFix" as it similarly spans the fracture and wrist joint, but provides the added advantage of all internal fixation and theoretically avoids complications associated with pins and prominent hardware. Over the years, authors have refined the technique and increased the indication to manage osteoporotic fractures of the distal radius, fractures with extensive articular,

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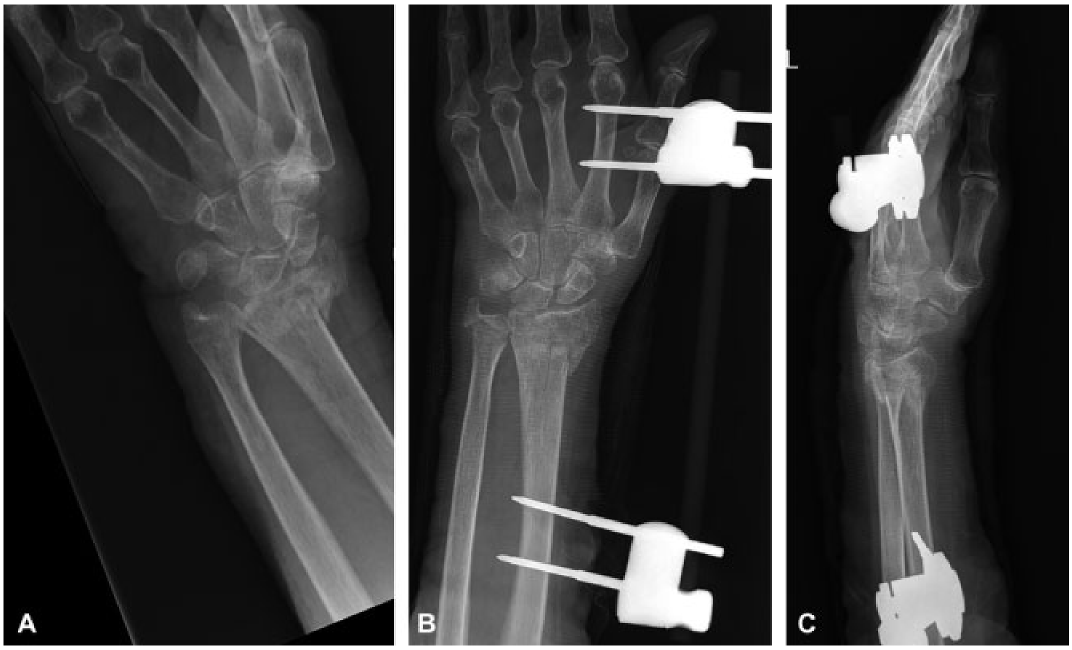

Fig. 1 (A–C) Distal radius fracture treated with a wrist-spanning dorsal bridge plate.

and/or metadiaphyseal comminution, or in cases of fracture with radiocarpal instability.[6–9] More recently, with the advent of anatomically designed low-profile bridge plates with locking screw technology, their indications have expanded to include its use in polytrauma patients and/or patients who need to ambulate with assistive devices through the injured wrist.[10]

There are advantages and disadvantages with an ExFix and bridge plate in the management of distal radius fractures. One of the main advantages of bridge plate is the avoidance of pin track infections or the inconvenience of prominent hardware. In addition, because it is placed below the skin, a bridge plate can be left in the position for a longer period of time. Alternatively, the main disadvantage of a bridge plate is the need for a secondary operation for plate removal.[11]

Despite these purported advantages, little is understood about the functional comparative difference between a bridge plate versus an ExFix technique. Therefore, to better understand the comparative advantages and disadvantages of these two fracture-fixation techniques for distal radius fractures, a meta-analysis was undertaken.

Fig. 2 (A–C) Distal radius fracture treated with external fixation.

Materials and Methods

Articles from January 1, 2005 to September 9, 2017 were queried on the PubMed database. This "modern" time period was used to minimize implant technology related variability. Search terms for the ExFix and bridge plate studies included "(external fixator) and distal and radius" and "(bridge or bridging or spanning) and (plate or plating) and distal and radius," respectively. All articles were reviewed and selected based on inclusion and exclusion criteria. Studies meeting inclusion criteria were case series, retrospective studies, observational cohort studies, and randomized controlled trials with available functional outcome data of wrist spanning ExFix and bridge plate fixation. Exclusion criteria included use of dynamic ExFix, nonspanning wrist ExFix, and ExFix or bridge plating augmented with any additional internal fixation.

Each article was reviewed and the following data were extracted: demographic data, AO (Arbeitsgemeinschaft für Osteosynthesefragen) fracture classification, functional outcome measures, postoperative radiographic parameters, and complications. For functional outcomes, we collected functional outcome data from the Disabilities of the Arm, Shoulder, and Hand (DASH) and the Gartland and Werly questionnaires. Radiographic parameters included radial height, radial inclination, volar tilt, and ulnar variance. Data from all studies were combined and compared across the two treatment teams using generalized linear models using SPSS, and descriptive statistics were performed.

Results

The literature initial search yielded 489 ExFix articles and 22 bridge plate articles for review. After applying the inclusion and exclusion criteria (►**Figs. 3** and **4**), 22 and six articles were remained for inclusion and exclusion, respectively (►**Table 1**). Overall, 172 patients were treated with bridge plating and 723 patients treated with ExFix.

The mean age for the bridge plate and ExFix groups were 56.9 and 53.9 years, respectively. The bridge plating group consisted of a higher proportion of male patients (55 vs. 35.8%, $p = 0.011$). Mean follow-up time was 17.3 and 18.9 months, respectively. Time to hardware removal for the bridge plate group was higher than the ExFix group (17.6 vs. 6.2 weeks, $p < 0.001$). The bridge plate group also consisted of more dominant extremities (70.6 vs. 50.4%, $p = 0.03$). While there were no significant differences in proportion of AO fracture type A (14 vs. 24.5%, $p = 0.31$) and C (80.1 vs. 76.9%, $p = 0.73$), the bridge plate group had a higher proportion of AO fracture type B (5.8 vs. 0.3%, $p = 0.013$). See ►**Table 2** for a comparison of additional variables and demographic factors.

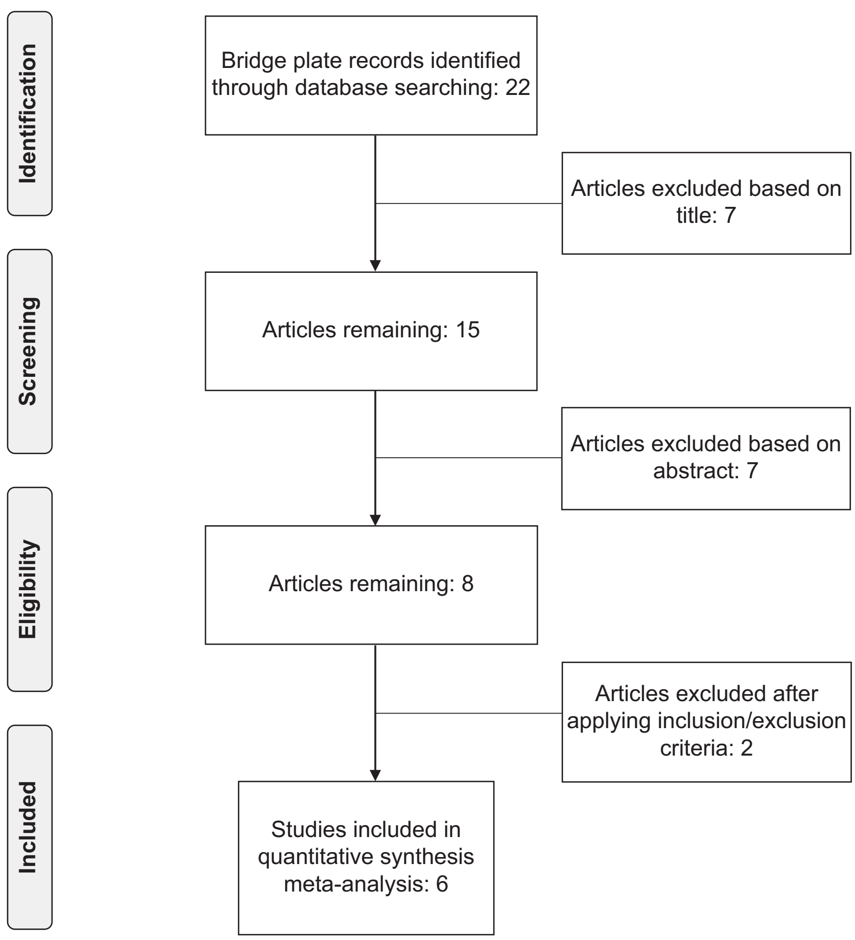

Fig. 3 Flow diagram of literature search for external fixation articles.

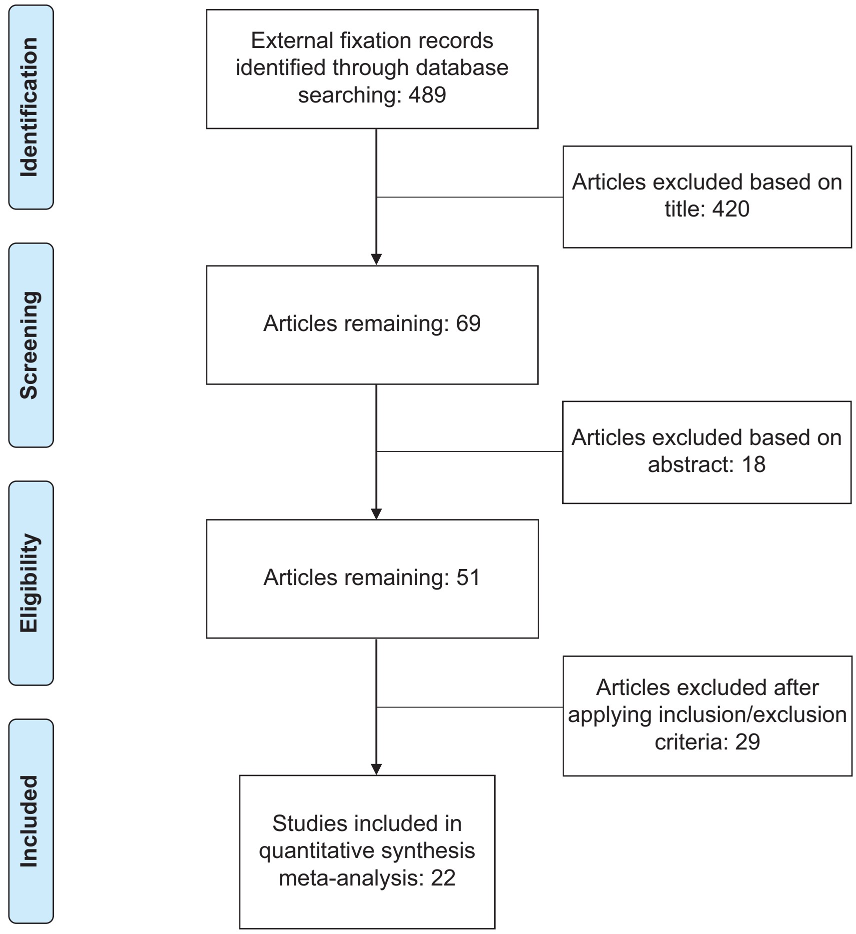

Fig. 4 Flow diagram of literature search for bridge plate articles.

The bridge plating group demonstrated higher rates of hardware failure compared with ExFix (4 vs. 1%, $p = 0.026$). The external fixator group demonstrated higher rates of infection (10 vs. 2%, $p = 0.05$) and complex-regional pain syndrome (4 vs. 1%, $p = 0.04$). Bridge plating demonstrated higher rates of excellent/good ratings under the Gartland and Werley outcome score compared with ExFix (91 vs. 83%, $p = 0.016$). Although ExFix demonstrated higher rates of nerve palsy and other nerve complications, this was not statistically significant (3 vs. 1%, $p = 0.063$). There were no statistically significant differences in DASH score, radiographic parameters (radial height, radial inclination, volar tilt, and ulnar variance). There were no differences in the rate of unplanned reoperations. See ►**Table 3** for a complete list of comparative outcomes between the bridge plating and ExFix groups.

Discussion

ExFix is a well proven technique in the management of distal radius fractures. Bridge plating is a newer technique that builds on the concept of spanning and fixing the reduced and distracted distal radius fracture but provides some additional potential benefits including less-prominent hardware complications, the ability to keep the hardware in position longer, and the ability to allow for immediate weight bearing across the fractured distal radius. Both techniques are useful to have in an upper extremity surgeon's armamentarium.

Our meta-analysis found several interesting findings. Bridge plating demonstrated lower rates of infection and complex regional pain syndrome, although had higher rates of hardware failure when compared with ExFix. The higher infection rate is not unexpected, given that pin tract infections are one of the known disadvantages to ExFix and a primary limitation to time to hardware removal.[12–17] Despite the differences in complication rates in infection, hardware failure, and complex regional pain syndrome, there was no difference in unplanned reoperations between the two groups. The majority of pin tract infections can be successfully treated with antibiotics; ultimately, only two patients from the external fixator group required a secondary irrigation and debridement operation for infection.[15] Hardware failure in the bridge plating group often occurred after 8 weeks, which would be anticipated to have occurred after the fracture had healed.[6,10,18] Since patients treated with Bridge Plate will undergo a planned secondary procedure for hardware removal, hardware failure in this group has less clinical significance if it occurs after fracture union. Complex regional pain syndrome occurred at a higher rate in the ExFix group and was commonly treated with

Table 1 Demographics for data evaluating outcomes after bridge plating and external fixation

Article authors	Year of publication	Design	Patients	Mean age (y)	AO type A *n* (%)	AO type B *n* (%)	AO type C *n* (%)	Follow-up (mo)	Hardware removal (wk)
Demographics for data evaluating outcomes after bridge plating									
Tinsley and Ilyas[10]	2018 (e-pub 2017)	Retrospective	11	72	4 (36)	0 (0)	7 (64%)	–	–
Lauder et al	2015	Retrospective	18	61	0 (0)	0 (0)	18 (100)	34.8	12
Dodds et al[18]	2013	Retrospective	25	54.6	0 (0)	7 (28)	18 (72)	6.6	26.5
Richard et al[8]	2012	Retrospective	33	70	0 (0)	0 (0)	33 (100)	10.8	17
Hanel et al[6]	2006	Retrospective	62	47.8	18 (29)	3 (5)	41 (66)		
Ruch et al[9]	2005	Retrospective	22	54.6	2 (9)	0 (0)	20 (91)	24.8	17.7
Total			**171**						
Demographics for data evaluating outcomes after external fixation									
Roh et al	2015	Prospective	38	55.3	0 (0)	0 (0)	38 (100)	12	5.3
Shukla et al	2014	Prospective	62	39	–	–	–	12	8
Kumbaraci et al[12]	2014	Retrospective	35	52.6	0 (0)	0 (0)	35 (100)	24.5	–
Williksen et al[13]	2013	Prospective	59	54	14 (24)	0 (0)	45 (76)	12	6
Jeudy et al	2012	Prospective	39	64.6	0 (0)	0 (0)	39 (100)	6	6
Grewal et al[14]	2011	Prospective	24	53.8	–	–	–	12	6
Richard et al[8]	2011	Retrospective	59	50	0 (0)	0 (0)	59 (100)	12	–
Wilcke et al	2011	Prospective	30	56	22 (73)	0 (0)	8 (27)	12	5
Gereli et al	2010	Retrospective	14	35	0 (0)	0 (0)	14 (100)	62.7	7.8
Hove et al	2010	Prospective	35	54	19 (54)	0 (0)	16 (46)	12	6
Belloti et al	2010	Prospective	49	59.2	–	–	–	24	6
Sato et al	2010	Retrospective	13	65.8	4 (31)	0 (0)	9 (69)	23	–
Aktekin et al[19]	2010	Retrospective	22	69.8	9 (41)	0 (0)	13 (59)	27	6
Abramo et al	2009	Prospective	24	48	4 (17)	0 (0)	20 (83)	12	–
Wei et al	2009	Prospective	22	55	10 (45)	0 (0)	12 (55)	12	–
Schmelzer-Schmied et al	2009	Retrospective	15	–	0 (0)	0 (0)	15 (100)	72	6
Egol et al	2008	Prospective	44	49.9	16 (36)	2 (5)	26 (59)	12	6
Leung et al[15]	2008	Prospective	49	–	0 (0)	0 (0)	49 (100)	24	–
Atroshi et al[16]	2006	Prospective	19	71	8 (42)	0 (0)	11 (58)	12	6
Kreder et al[17]	2006	Prospective	44	52.4	35 (80)	0 (0)	19 (43)	44	–
Wright et al[20]	2005	Retrospective	11	50	3 (27)	0 (0)	8 (73)	24	–
Hegeman et al[21]	2005	Retrospective	16	67	0 (0)	0 (0)	16 (100)	48	6

therapy.[12,13,19–21] While this difference may influence functional and satisfaction outcomes, it had negligible influence on unplanned reoperation.

Patients treated with Bridge Plate demonstrated higher Gartland and Wearly scores compared with ExFix. The Gartland and Werley scoring system was initially described in 1951.[22] While it is used widely in the literature, it has not been validated by studies to date. When comparing scores using the validated DASH questionnaire, there were no differences between the two groups.[23,24] With this in mind, we are not able to conclude that one treatment group had superior clinical outcomes than the other.

Limitations

There are limitations to this study. We were not able to find any comparative studies in our literature search, evaluating the efficacy and outcomes of bridge plating and ExFix within a single cohort. Furthermore, there are a limited number of bridge plating studies in the literature, consisting mostly of retrospective case series. This limited our ability to generate and compare effect sizes for outcome measures.

Another limitation is lack of randomization which is demonstrated by the differences in baseline patient characteristics between the bridge plating and external fixator

Table 2 Comparison of additional variables and demographic factors

Demographic data			
Variable	**Bridge plate mean**	**External fixation mean**	***p*-Value**
Age (y)	56.90 (47.84–65.96)	53.85 (49.84–57.86)	0.532
Male gender	88 (55.0%)	215 (35.8%)	0.011
Follow-up (mo)	17.29 (6.71–27.86)	18.85 (14.08–23.61)	0.784
Time to removal of hardware (wk)	17.63 (14.06–21.21)	6.20 (5.61–6.78)	<0.001
Dominant extremity *n*(%)	72 (70.6)	138 (50.4)	0.028
AO fracture type A *n*(%)	24 (14.0)	144 (24.5)	0.308
AO fracture type B *n*(%)	10 (5.8)	2 (0.3)	0.013
AO fracture type C *n*(%)	137 (80.1)	452 (76.9)	0.729

Table 3 Complete list of comparative outcomes between the bridge plating and external fixation groups

Continuous outcomes for bridge plate vs. external fixation				
Variables	**Bridge plate mean (95% CI)**	**External fixation mean (95% CI)**	***p*-Value**	
Radial height (mm)	10.30 (10.30–10.30)	10.11 (8.97–11.25)	0.708	
Radial inclination (degrees)	20.90 (18.68–23.12)	21.31 (19.62–23.01)	0.760	
Volar tilt (degrees)	4.10 (3.14–5.06)	4.56 (3.09–6.04)	0.589	
Ulnar variance (mm)	0.72 (0.08–1.37)	1.24 (0.73–1.75)	0.202	
DASH score	23.80 (8.02–39.58)	17.16 (10.40–23.92)	0.416	
Categorical outcomes for bridge plate vs. external fixation				
Variables	**Bridge plate est. rate (95% CI)**	**External fixation est. rate (95% CI)**	**Odds ratio**	***p*-Value**
Infections	2 (1–10)	10 (7–14)	0.21	0.050
Iatrogenic fracture	0 (0–0)	0 (0–1)	–	–
Hardware failure	4 (1–10)	1 (0–2)	5.22	0.026
Complex regional pain syndrome	1 (0–3)	4 (2–7)	0.14	0.040
Nerve palsy and complications	1 (0–3)	3 (2–6)	0.16	0.063
Scar complications	1 (0–8)	2 (1–3)	0.77	0.810
Late carpal tunnel syndrome	0 (0–0)	3 (1–6)	–	–
Loss of reduction	0 (0–0)	2 (1–5)	–	–
Malunion or delayed union	0 (0–0)	3 (1–9)	–	–
Arthritis	0 (0–0)	0 (0–3)	–	–
Pseudoarthrosis	0 (0–0)	0 (0–1)	–	–
Finger stiffness	6 (1–29)	3 (1–10)	2.30	0.492
Shoulder capsulitis	0 (0–0)	1 (0–2)	–	–
Unplanned reoperation	4 (1–10)	3 (2–6)	1.11	0.880
Gartland and Werley: excellent/good	91 (91–91)	83 (72–90)	2.09	0.016

Abbreviations: CI, confidence interval; DASH, Disability of the Arm, Shoulder, and Wrist; est. estimated.

groups. The bridge plating group had a higher proportion of male patients. Furthermore, the bridge plating group had more dominant extremity injuries and AO fracture type B. However, while there are differences between the two groups, it is unclear if these differences would have a significant impact on clinical outcome.

Conclusion

Bridge plating appears to be a suitable alternative to ExFix for distal radius fractures. However, there are limited number of comparative studies to draw any definite conclusions in terms of clinical superiority and safety. Future directions would include prospective comparative studies between bridge plating and ExFix, evaluating for functional and radiographic outcomes.

Note
This study was conducted at Rothman Institute at Thomas Jefferson University, Philadelphia, PA.

Conflict of Interest
None declared.

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