Early loss of fixation after surgical treatment of distal radius fractures: Does the number of screws matter?

Lili Schindelar^{*}, Philip Petrucelli, William Wang, Richard McEntee, Justin Kistler, Kevin Laroche, Pedro Beredjiklian, Jacob Tulipan

The Rothman Orthopaedic Institute at Thomas Jefferson University, Philadelphia, PA, 19107, USA

ARTICLE INFO

Keywords:

Distal radius fracture
Failure of fixation
Open reduction internal fixation
Screw number

ABSTRACT

Fixation methods in distal radius fractures has been studied biomechanically, but studies evaluating clinical correlation of that data are lacking. We hypothesize that the use of unthreaded pegs and decreased screw number would correlate with an early failure of fixation. There were 50 operatively treated distal radius fractures with initial post-operative radiographs that demonstrated loss of fixation. An age, BMI, and fracture-type matched cohort of 50 non-failed distal radius fractures was used for comparison. The average number of distal screws in the failed fixation group was 5.3 compared to 4.8 in the group with no loss of fixation ($p = 0.07$). The average number of proximal shaft screws used in the failed fixation group was 3.2 compared to 3.2 in the control group ($p = 0.60$). There was no difference between the use of pegs in either group. There was a significant difference between distal screw number between constructs that failed from distal screw pullout as compared to the control group, 5.6 vs. 4.8 ($p = 0.0001$). In conclusion, there was no difference in the number of proximal screws used in distal radius fractures that demonstrated loss of early fixation. Additionally, having more than five screws in the distal fragment had a higher rate of failure from distal screw pullout, however this was likely confounded by the more severe intra-articular fractures that had additional fixation applied in an attempt to increase stability. Finally, using smooth pegs or screws in the distal fragment made no difference in loss of fixation.

1. Introduction

The use of plates has been well established as a reliable treatment to achieve anatomic reduction and stable fixation in unstable distal radius fractures. The past decade has seen advances in implant design and fixation technique to improve outcomes after plating of distal radius fractures. With newer volar plates that offer monoaxial fixed-angle or polyaxial variable-angle locking screw-plate design, there are many options for not only the type of plate used, but also the number and type of screws that are used for fixation.¹ With modern implants, loss of fixation is an uncommon complication of distal radius fracture open reduction and internal fixation, with an estimated incidence of 0.9–1.3%.^{2–4}

There have been a number of biomechanical studies examining optimal implant configurations, including a systematic review by Ramavath et al., that evaluated the best biomechanical outcomes of volar plating for distal radius fractures. The evidence revealed that it was not necessary to fill all available distal screw holes, and there was

little data to support using two rows of distal screws over one row.⁵

However, there is currently a lack of literature examining the clinical loss of fixation of distal radius fractures treated with surgical fixation to determine the ideal screw numbers and fixation construct. Thus, the purpose of this study was to evaluate distal radius fractures complicated by early fixation failure, and to compare the fixation construct to a non-failed, matched cohort to determine if screw number or type of construct leads to early failure of fixation. We hypothesize that the use of unthreaded pegs and decreased screw number would correlate with an early failure of fixation.

2. Methods

A query was performed of all distal radius fractures treated surgically from May 2013 through July 2019 from one institution. The first follow up post-operative radiographs were retrospectively reviewed to assess for fixation failure. Failure of fixation was determined by the agreement of the two senior authors based on maintenance of radial inclination,

^{*} Corresponding author. The Rothman Institute, 925 Chestnut Street, 5th Floor, Philadelphia, PA, 19107, USA.

E-mail addresses: lschindelar@gmail.com, lili.schindelar@jefferson.edu (L. Schindelar).

radial height, volar tilt, and intra-articular step-off. If there was disagreement between the two senior authors on whether there was loss of fixation, these constructs were not included. All constructs were evaluated for Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification of the fracture, the number of distal screws, the number of shaft screws, use of smooth pegs in the distal fragment, the number and type of plates used, and use of supplemental fixation, including Kirshner wires or interfragmentary screws. Post-operative radiographs were compared to intra-operative imaging to determine whether there was a poor intra-operative reduction or if loss of fixation occurred after leaving the operating room. Demographics were collected for all patients. An age, gender, body mass index (BMI), and AO fracture-type one to one ratio matched cohort of non-failed distal radius fractures was used to compare the failed fixation constructs to a control.

2.1. Statistical analysis

A post hoc power analysis was conducted based on the average number of distal screws. With a sample size of 33 distal screw pullout cases and 49 control cases, with means of 5.58 (SD 1.09) and 4.73 (1.41), effect size was 0.67. With an assumed alpha of 0.05, the power is 0.907, which indicates this study is adequately powered. T-test and chi-squared test were performed to compare groups using SPSS (IBM, New York).

3. Results

A total of 741 radiographs were reviewed, of which 50 (6.7%) were found to have loss of fixation. Demographics can be seen in Table 1. The first follow up radiograph was taken on average 23 days post-operatively in the loss of fixation group, and 21 days post-operatively in the control group. The average number of distal screws in the failed fixation group was 5.3 compared to 4.8 in the group with no loss of fixation ($p = 0.07$). The average number of proximal shaft screws used in the failed fixation group was 3.2 compared to 3.2 in the control group ($p = 0.60$). Pegs were used in 20% of cases in both groups ($p = 1.00$). Volar plates were used in 88% of the loss of fixation group, and 86% of the no loss of fixation group ($p = 1.00$). Dorsal plates were used in 12% of the failed group, compared to 14% of the non-failed group ($p = 1.00$). The majority of plates in both groups were locking plates, 96% versus 94% in the loss of fixation and no loss of fixation groups, respectively ($p = 1.00$, Table 2).

The mode of fixation loss can be seen in Table 3. The majority failed by distal screw pullout (66%), followed by failure to capture the distal fragment (24%). When the screw number in the constructs that failed from distal screw pullout were compared to the control group, there was a significant difference in the mean number of distal screws; 5.6 in the distal screw pullout group compared to 4.8 in the no loss of fixation group ($p = 0.0001$). The mean number of proximal screws were not different between the groups; 3.0 in distal screw pullout group versus 3.2 in the no loss of fixation group ($p = 0.14$). The prevalence of unthreaded peg use did not differ between groups (Table 4). There was

Table 1
Demographics.

Demographics	Loss of Fixation	No Loss of Fixation
Age, year	65	65
BMI	30	29
Female, n (%)	39 (78.0)	39 (78.0)
AO Type A Fracture, n (%)	15 (30.0)	15 (30.0)
AO Type B Fracture, n (%)	4 (13.3)	4 (13.3)
AO Type C Fracture, n (%)	30 (60.0)	30 (60.0)

Legend: BMI= Body Mass Index, AO = Arbeitsgemeinschaft für Osteosynthesefragen.

Table 2

Construct Characteristics: Loss of Fixation vs. No Loss of Fixation.

Construct Characteristics	Loss of Fixation	No Loss of Fixation	p value
Total, n	50	50	
Avg Distal Screws, n	5.3	4.8	0.07
Avg Proximal Screws, n	3.2	3.2	0.60
Distal Pegs, n (%)	10 (20.0)	10 (20.0)	1.00
Locking Plates, n (%)	48 (96.0)	47 (94.0)	1.00
Volar Plates, n (%)	44 (88.0)	43 (86.0)	1.00
Dorsal Plates, n (%)	6 (12.0)	7 (14.0)	1.00
Multiple Plates, n (%)	1 (2.0)	2 (4.0)	1.00
Supplemental Fixation, n (%)	7 (14.0)	4 (8.0)	0.52

Legend: Avg = average.

Table 3

Mode of failure in constructs with loss of fixation.

Mode of Failure	
Distal Screw Pullout, n (%)	33 (66.0)
Proximal Screw Pullout, n (%)	1 (2.0)
Failure to Capture Distal Fragment, n (%)	12 (24.0)
Screw-Plate Interface Failure, n (%)	1 (2.0)
Pin Failure, n (%)	1 (2.0)
Poor Intraoperative Reduction, n (%)	4 (8.0)

Table 4

Number of Screws: Loss of Fixation with Distal Screw Pullout vs. No Loss of Fixation.

Number of Screws: Distal Screw Pullout vs. No Loss of Fixation			
	Distal Screw Pull Out	No Loss of Fixation	p value
Avg Distal Screws, n	5.6	4.8	0.0001
Avg Proximal Screws, n	3.0	3.2	0.14
Pegs Used, %	24.2	20.0	0.79

Legend: Avg = average.

no difference in the patient demographics or AO fracture type between the constructs that failed by distal screw pullout and the control group. When a subgroup analysis was performed to examine AO fracture type, only AO type C fractures in the distal screw pullout group used significantly more distal screws than the control group, 5.5 versus 4.8 ($p = 0.04$) (Table 5).

4. Discussion

The current study examines clinical loss of fixation after surgical fixation of distal radius fractures to determine ideal screw numbers and fixation constructs. We found that the number of shaft screws used was similar between constructs that exhibited loss of fixation and those that

Table 5

Number of Screws: Loss of Fixation with Distal Screw Pullout vs. No Loss of Fixation, Stratified by AO Fracture Type.

Subgroup Analysis by AO Fracture Type			
	Distal Screw Pullout	Control	p
AO Type A			
Distal Screws, n	5.7	4.9	0.17
Proximal Screws, n	3.0	3.0	1.00
AO Type B			
Distal Screws, n	6.0	4.3	0.24
Proximal Screws, n	2.5	2.8	0.63
AO Type C			
Distal Screws, n	5.5	4.8	0.04
Proximal Screws, n	3.1	3.4	0.09

Legend: AO = Arbeitsgemeinschaft für Osteosynthesefragen, Avg = average.

did not. Additionally, using greater than five distal screws correlated with a higher rate of loss of fixation from distal screw pullout.

There exist many biomechanical studies aimed at determining the ideal number and configuration of screws in a volar plate to optimize fixation of distal radius fractures. Jung et al. performed a biomechanical study to determine the minimum number of screws needed for sufficient stability of an unstable extra-articular distal radius fracture.⁶ They concluded that while filling all screw holes in the volar plate (seven distal and three shaft screws) was biomechanically stiffer as compared to using four distal and two shaft screws, there was no difference in compression testing representing physiological load, and thus the minimal screw number is acceptable.⁶ In our study, we found that the number of shaft screws used had no association with early loss of fixation.

With respect to the distal screw configuration, biomechanical literature supports not filling all the distal screw holes.^{5,7,8} Weninger et al. found there was no difference in stiffness between using screws in just the distal row or in both proximal and distal rows, concluding there was no mechanical advantage of using two distal rows.⁹ Similarly, Ramavath et al. conducted a systematic review of biomechanical studies and found that it was not necessary to fill all available distal screw holes and there was little evidence to support using two distal rows over one.⁵ Crosby et al. studied the utility of using all available distal locking screws versus using half of them and found that using half did not decrease construct stability.⁸

There are limited radiographic studies evaluating the use of two distal rows versus using one. Teunis et al. performed a radiographic evaluation of distal radius fractures treated with volar plating after one year and found there was no difference in fracture position or clinical outcomes when comparing using one or two distal rows of screws. Thus, they recommend using one screw row to decrease cost, surgical time, and risk of misplaced screws.¹⁰ Another retrospective radiographic study by Neuhaus et al. compared outcomes of distal radius fractures treated with one or two rows of distal screws and showed maintenance of fracture reduction in intra-articular and extra-articular fractures in both groups, concluding there is no advantage of two rows of distal screws over a single row.¹¹ Current literature support the use of the minimum number of screws necessary in the distal fragment, as extra screws increase cost and may increase the risk of complications like tendonitis or attrition.^{7,8}

Our data is supported by the current literature; the number of distal screws did not correlate with a loss of fixation between the failure of fixation group and the control group. However when we performed a subgroup analysis comparing those constructs that failed from distal screw pullout to those that did not have loss of fixation, distal screw number was significantly different. Having greater than five screws in the distal fragment was associated with distal screw pullout and early failure of fixation. Of note, there were no differences in demographics or AO fracture type between these two cohorts. However, when we further stratified by AO fracture type, the number of distal screws were significantly different between the distal screw pullout group and the control group only in the AO type C fractures. This finding may help to explain this correlation; that surgeons tend to use more distal screws if the fracture is a more tenuous intra-articular fracture, which are more prone for failure. This provides new data on the ideal number of distal screws for a stable construct; not only are more screws more expensive, but they may not provide additional stability for particular AO type C fractures.

The most common mode of failure in the loss of fixation group was distal fragment screw pullout. In a review of nine cases of mechanical failure of volar locking plates for distal radius fractures, Foo et al. found screw pullout to be the most common failure type, seen in five patients.¹² The second most common reason for loss of fixation was failure of the screws to capture the distal fragment. Both of these failures are at the distal aspect of the construct, where comminution and poor bone quality affect the stability.

We found no difference in fixation with the use of smooth pegs in the

distal segment. Biomechanical studies comparing the use of smooth locking pegs versus locking screws have found that smooth pegs were significantly weaker than the locking screws.^{13,14} However, in a clinical study, Boretto et al. found no difference in stability between locking smooth pegs or locking screws used in volar plating of intra-articular fractures, a finding supported by this study.¹⁵

The present study has limitations. First, given the retrospective study design, it is subject to the bias of retrospective work and reliance on accurate data. Second, it is subject to intra-observer bias as there were multiple reviewers of radiographs to determine loss of fixation. However, this was mitigated by having the two senior authors both review the radiographs thought to have loss of fixation, and only after agreement of both authors was it counted as a loss of fixation. Despite these limitations, the current study provides novel data that adds to the clinical evaluation of distal radius fractures treated surgically.

In conclusion, there was no difference in the number of proximal screws used in distal radius fractures that demonstrated loss of early fixation. Additionally, having more than five screws in the distal fragment had a higher rate of failure from distal screw pullout, however this was likely confounded by the more severe intra-articular fractures that had additional fixation applied in an attempt to increase stability. Finally, using smooth pegs or screws in the distal fragment made no difference in loss of fixation.

Source of funding

There were no conflicts of interest or sources of funding declared for any authors.

Declaration of competing interest

There were no conflicts of interest or sources of funding declared for any authors.

References

- 1 Inagaki K, Kawasaki K. Distal radius fractures—Design of locking mechanism in plate system and recent surgical procedures. *J Orthop Sci.* 2016;21(3):258–262. <https://doi.org/10.1016/j.jos.2015.12.022>.
- 2 Lattmann T, Meier C, Dietrich M, Forberger J, Platz A. Results of volar locking plate osteosynthesis for distal radial fractures. *J Trauma Inj Infect Crit Care.* 2011;70(6):1510–1518. <https://doi.org/10.1097/TA.0b013e3181f13c6a>.
- 3 Soong M, van Leerdam R, Guitton TG, Got C, Katarincic J, Ring D. Fracture of the distal radius: risk factors for complications after locked volar plate fixation. *J Hand Surg.* 2011;36(1):3–9. <https://doi.org/10.1016/j.jhsa.2010.09.033>.
- 4 Esenwein P, Sonderegger J, Gruenert J, Ellenrieder B, Tawfik J, Jakubietz M. Complications following palmar plate fixation of distal radius fractures: a review of 665 cases. *Arch Orthop Trauma Surg.* 2013;133(8):1155–1162. <https://doi.org/10.1007/s00402-013-1766-x>.
- 5 Ramavath A, Howard N, Lipscombe S. Biomechanical considerations for strategies to improve outcomes following volar plating of distal radius fractures. *J Orthop.* 2019;16(5):445–450. <https://doi.org/10.1016/j.jor.2019.04.006>.
- 6 Jung H-S, Jung HS, Baek S-H, Lee JS. How many screws are needed for reliable stability of extra-articular nonosteoporotic distal radius fractures fixed with volar locking plates? *Clin Orthop Surg.* 2020;12(1):22. <https://doi.org/10.4055/cios.2020.12.1.22>.
- 7 Moss DP, Means KR, Parks BG, Forthman CL. A biomechanical comparison of volar locked plating of intra-articular distal radius fractures: use of 4 versus 7 screws for distal fixation. *J Hand Surg.* 2011;36(12):1907–1911. <https://doi.org/10.1016/j.jhsa.2011.08.039>.
- 8 Crosby SN, Fletcher ND, Yap ER, Lee DH. The mechanical stability of extra-articular distal radius fractures with respect to the number of screws securing the distal fragment. *J Hand Surg.* 2013;38(6):1097–1105. <https://doi.org/10.1016/j.jhsa.2013.02.038>.
- 9 Weninger P, Dall'Ara E, Drobetz H, et al. Multidirectional volar fixed-angle plating using cancellous locking screws for distal radius fractures – evaluation of three screw configurations in an extra-articular fracture model. *Wien Klin Wochenschr.* 2011;123(1–2):4–10. <https://doi.org/10.1007/s00508-010-1488-9>.
- 10 Teunis T, Jupiter J, Schaser KD, et al. Evaluation of radiographic fracture position 1 year after variable angle locking volar distal radius plating: a prospective multicentre case series. *J Hand Surg Eur.* 2017;42(5):493–500. <https://doi.org/10.1177/1753193417690478>.
- 11 Neuhaus V, Badri O, Ferree S, Bot AGJ, Ring DC, Mudgal CS. Radiographic alignment of unstable distal radius fractures fixed with 1 or 2 rows of screws in volar locking

- plates. *J Hand Surg.* 2013;38(2):297–301. <https://doi.org/10.1016/j.jhsa.2012.10.040>.
- 12 Foo T-L, Gan AW, Soh T, Chew WY. Mechanical failure of the distal radius volar locking plate. *J Orthop Surg.* 2013;21(3):332–336. <https://doi.org/10.1177/230949901302100314>.
 - 13 Martineau PA, Waitayawinyu T, Malone KJ, Hanel DP, Trumble TE. Volar plating of AO C3 distal radius fractures: biomechanical evaluation of locking screw and locking smooth peg configurations. *J Hand Surg.* 2008;33(6):827–834. <https://doi.org/10.1016/j.jhsa.2008.01.006>.
 - 14 Weninger P, Dall'Ara E, Leixnering M, et al. Volar fixed-angle plating of extra-articular distal radius fractures—a biomechanical analysis comparing threaded screws and smooth pegs. *J Trauma Inj Infect Crit Care.* 2010;69(5):E46–E55. <https://doi.org/10.1097/TA.0b013e3181c6630e>.
 - 15 Boretto JG, Pacher N, Giunta D, Gallucci GL, Alfie V, De Carli P. Comparative clinical study of locking screws versus smooth locking pegs in volar plating of distal radius fractures. *J Hand Surg Eur.* 2014;39(7):755–760. <https://doi.org/10.1177/1753193413517806>.