Volar plate fixation after distal radius fracture are as stable as a healed plated distal radius fracture.

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Abstract

Background: Fall onto an outstretched hand accounts for about 80% of distal radius fractures. Volar plating is utilized due to its stronger and stable fixation. Stable fracture fixation permits earlier range of motion and activity. The purpose of this study was to compare the peak load failure of volar plate fixation of an unstable type of distal radius fracture with an intact distal radius after simulating a fall.

Methods: Sawbone radii have been shown to mimic human cadaveric bone. Five fractured distal radii were compared to five intact distal radii. A standard unstable, intra-articular 3-part distal radius fracture was utilized for the fracture group. Synthes 2.4 mm Variable Angle LCP Distal Radius System plates were implanted onto the sawbones in the standard fashion. A weighted swingarm was employed to simulate the rotational fall onto an outstretched hand until failure of the plate-sawbone construct.

Results: Specimens first failed on the radius shaft just proximal to the plate. Further testing on the plated end of the distal radius of both groups then resulted in fixation failure in the control group at 150N compared to 145N of the fractured group.

Conclusion: Volar plating of a distal radius fracture with fixed angle locking technology appears to be as stable in its initial phase after immediate fixation as it is after it heals with the plate in place. Furthermore, individuals who sustain a fall after distal radius fracture fixation are likely to fracture at the radial shaft proximal to the plate and at lower force.

Keywords: Distal radius fracture, Volar plate, peri-implant fracture, Radial shaft fracture, Sawbone, Distal radius impaction fracture, Healed distal radius fracture.

Introduction

Fractures of the distal radius are one of the most common orthopaedic injuries, accounting for approximately 12 – 17% of all fractures, with fall onto an outstretched hand accounting for about 80% of incidents [1-3]. Fractures can range from a simple pattern such as extra-articular nondisplaced to highly comminuted displaced intra-articular fractures depending on the energy sustained at the site of injury or the susceptibility to injury such as is seen in individuals with osteoporosis. More commonly, volar plating is being utilized for fixation due to its stronger and more stable fracture fixation as well as its lower risk of complications compared to dorsal plating [4-6]. Furthermore, this stable fracture fixation permits early functional rehabilitation with earlier range of motion and return to activity while decreasing the complication of joint stiffness and therefore may improve long term outcomes [7,8].

With earlier return to activity or with individuals who are prone to falling, there is a risk of sustaining another injury onto the same distal radius fracture after volar plating fixation. This may occur soon after the surgery or later after the fracture has healed. The purpose of this study was to compare the peak load failure of volar plate fixed-angle fixation of an unstable type of distal radius fracture with an intact distal radius after simulating a fall. Our hypothesis presupposed that there would be no difference between the groups in terms of peak load to failure due to the strength and protection of the volar distal radius plates.

Materials and Methods

Sawbone radii with white plastic cortical shell and foam cancellous core have been shown to mimic human cadaveric bone strength and therefore a good substitute model to utilize in testing [9,10]. Based on a previous biomechanical study of peak to load failure of volar plates, a power analysis of a suspected control mean of 400 +/- 110 with experimental group mean of about 200, an alpha equal to 0.05 and beta of 0.2, resulted in a sample size for each group of 5 . Five fractured distal radii (fracture group) were compared to five intact distal radii (control group). A standard unstable, intra-articular 3-part distal radius fracture was utilized for the fracture group, which was a fracture of the radial column,

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intermediate column and shaft (Figure 1). A Synthes 2.4 mm Variable Angle LCP Distal Radius System plate was utilized, which included 7 distal locking 2.4 mm screw holes and 3 proximal shaft nonlocking 2.7 mm screw holes. Plates were implanted onto the sawbones in the standard bicortical fashion leaving no fracture gap, utilizing all 7 distal locking holes and all 3 proximal holes. Both groups were similar in every detail except the created fractures in the test group (fracture group).

The average fall onto an outstretched hand is about the height of the elbow falling rotationally, and the average height of the elbow is about 41 inches with average wrist extension during such a fall being 80 degrees [11,12]. Each distal radius was placed into a clamp holding the proximal radius and at 80 degrees of inclination to the point of impact of the force vector. A swingarm 41 inches long with a weight on the end was employed to simulate the rotational fall onto an outstretched hand (Figure 2). Weight was increased by 5 pounds until failure of fixation of the plate-sawbone construct. Failure was defined as the plate no longer providing fixation, that is, holding the bone fracture fragments of the distal radius together.

Paired t-test was utilized as both groups were matched except for one difference being the fracture in the test group and assuming a normal distribution of data.

This article does not contain any studies with human or animal subjects

Results

All plate-sawbone constructs first failed on the radius shaft just proximal to the plate on the distal radius except for one of the controls, which fractured in the most proximal screw hole. The average distance from the plate to the shaft fracture in the control group was 1.5 cm (range -0.5 – 3 cm) and 2.3 cm (range 1.5 – 3 cm) in the fractured group. The average force of failure in the control group was 78 N (range 70 – 84 N) compared to 73 N (range 70 – 84 N) in the fractured group. The differences were not significant (Table 1).

Testing was continued in order to determine the peak to load failure of the plated end of the distal radius, which became the second failure point. The remaining plate-sawbone construct, which included the entire bone under the plate was reclamped at the proximal end and positioned as before with 80 degrees of inclination to the force vector. The control group distal end of the radius developed a similar fracture pattern to the fracture group with a fracture of the radial column, intermediate column and shaft just prior to the failure of the plate-sawbone construct, but continued to hold the fractured bone together. On the next round of testing, the control group plate-sawbone constructs then failed and similarly to the fractured group

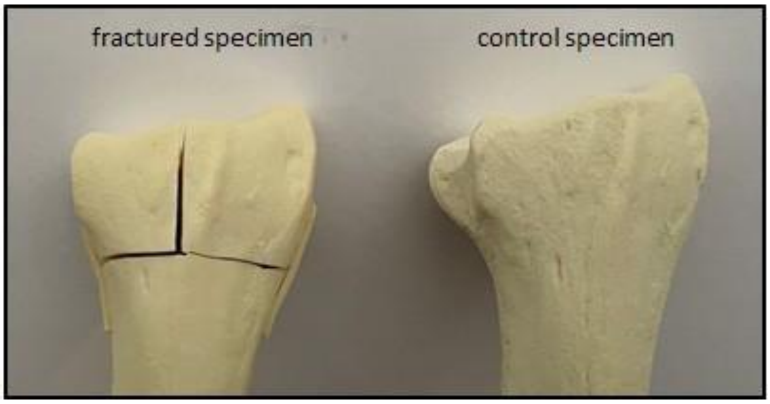

Figure 1. *Fractured specimen vs control specimen.*

Figure 2. *Radius was placed into a clamp holding the proximal radius and at 80 degrees of inclination to the point of impact of the force vector. A swingarm with a weight on the end was employed to simulate the rotational fall onto an outstretched hand.*

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by sustaining increased comminution of the main fracture fragments and the constructs falling apart (Figure 3). There was no fracture proximal to the end of the distal radius in the plated shaft portion and no plate breakage in either group. The average force of failure in the control group was 150 N (range 117 – 211 N) compared to 145 N (range 117 – 211 N) in the fractured group. The differences were not significant (Table 2).

Discussion

Distal radius fractures are one of the most common orthopaedic injuries and unstable forms are usually repaired with volar plate fixation. Unfortunately, nearly 50% of all distal radius fractures occur in patients aged over 65 years, which may be due to some gait or postural unsteadiness which in turn causes the fall . This falling can also occur in the postoperative period after volar plating during healing or even long after the distal radius has healed. The model we chose was to try and replicate an actual falling scenario, with falling from an average height and with a rotational vector of force. Sobky et al created a sawbone plate construct with a wedge of metaphysis excised so that the force would be focused on the plate itself. In that study, the Synthes plate failed just below 400 N. Therefore we expected the failure point to be below that level (Figure 4). Demonstrates the results of our testing. Both control group and fractured group initially failed by sustaining a fracture proximal to the plate. This empirically makes sense as the stiffness of distal radius plates are higher than that of bone and protective of the bone underneath. This effect is also observed in practice with individuals who have a distal radius plate in place and sustain a fall. Additionally, this may also result from stress shielding and subsequent weakening of bone at the area just proximal to the plate in vivo.

The next mode of failure was at the distal end of the radius within the area of the distal set of locking screws. It took about twice the amount of force to cause fracturing and loss of fixation of the plated bone compared to the first failure

Table 1: *Comparison of Control Group vs Fractured Group at the first peak to load failure, which occurred on the radius proximal shaft to the plate-sawbone interface in all samples, except in the control sample #2 at the most proximal screw hole of the plate on the radius shaft. P-values= 0.40 and 0.37 respectively.*

Specimen#	**Fracture Distance from Plate (cm)**	**Peak Load Failure #1 (Nm)**
Control		
1	1	84
2	-0.5	84
3	2	70
4	2	84
5	3	70
Mean	1.5	78.4
SD	1.3	7.7
SEM	0.6	3.4
Fractured		
1	3	70
2	3	70
3	1.5	84
4	2	70
5	2	70
Mean	**2.3**	**72.8**
SD	**0.7**	**6.3**
SEM	**0.3**	**2.8**

Figure 3. *After peak to load failure resulting in a comminuted end of the plated distal radius in a control sample (unfractured group).*

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Table 2: *Comparison of Control Group vs Fractured Group at the second peak to load failure, which occurred on the distal end of the radius at the plate-sawbone interface. P-values= 0.97.*

Specimen#		Specimen#	
Control	**Failure #2 (Nm)**	**Fractured**	**Failure #2 (Nm)**
1	140	1	117
2	140	2	140
3	140	3	140
4	211	4	117
5	117	5	211
Mean	127.8	Mean	124.6
SD	33.8	SD	35.8
SEM	15.1	SEM	16

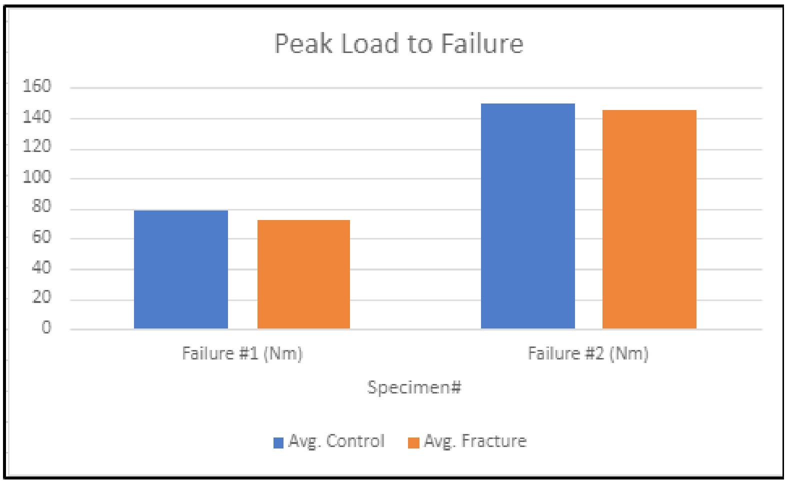

Figure 4. *Comparison of the two peak load to failure results.*

point. The control group started to fail by developing a similar fracture pattern to the experimentally fractured group. Both groups then completely failed by sustaining comminution of the distal radius and the construct losing fixation of the fracture fragments. The amount of force to displace a newly repaired fracture (experimental group) was nearly the same as the nonfractured control group. One of the challenging issues to deal with during the time of healing is how long should an individual be immobilized for sufficient healing to occur. The results of the second testing of peak load to failure implies that a newly repaired distal radius fracture that is repaired with stable fixation is nearly as strong as a healed plated distal radius, which can be represented by the control group of a plated nonfractured sawbone. Therefore, a newly repaired stable distal radius fracture should be able to start early rehabilitation exercises soon after surgery.

Limitations of the study include the small number of specimens for each group to obtain a result with a level of significance. However, the results were quite similar to each other between the control group and the fracture group and a minute difference would not significantly impact treating each group differently from each other clinically. Additionally, we had calculated the power analysis based on a study using a more concentrated pointed area of force on one aspect of the distal radius and is directed axially. The focus of that study was evaluation of the strength of the plate and not a sawbone-plate construct. Johnston et al demonstrated that it took about 30% less force with an off-axis load to failure than an axial load [13]. We attempted to replicate more of a real-world impaction by having the force spread across the distal radius and angular force application of 80 degrees. This can account for the lower values in our study compared to other studies [14]. In reality, the ulna and palm also sustain some of the force vector, absorbing some of the energy, and therefore it may take a stronger force to impart a distal radius fracture. Additionally, due to the multiple impacts until ultimate loss of fixation adds to weakening of the tested constructs and likely lower lesser predicted value of failure; however, the values were similar to the Sobky et al biomechanical load until failure comparison of several volar distal radius plates.

In conclusion, volar plating of a distal radius fracture with fixed angle locking technology appears to be as stable in its initial phase after immediate fixation as it is after it heals with the plate in place. Furthermore, an individual who sustains a fall after distal radius fracture fixation is likely to fracture at the radial shaft proximal to the plate and at lower force.

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Conflict of Interest

The author(s) certify that there is no conflict(s) of interest to declare.

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References

1. Nana AD, Joshi A, Lichtman DM. Plating of the distal radius. J Am Acad Orthop Surg. 2005;13(3):159-171.
2. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006;37(8):691-697.
3. Court-Brown CM, Clement ND, Duckworth AD, et al. The changing epidemiology of fall-related fractures in adults. Injury. 2017;48(4):819-824.
4. Fares AB, Childs BR, Polmear MM, et al. Dorsal Bridge Plate for Distal Radius Fractures: A Systematic Review. J Hand Surg Am. 2021;46(7):627.e1-627.e8.
5. Osada D, Viegas SF, Shah MA, et al. Comparison of different distal radius dorsal and volar fracture fixation plates: a biomechanical study. J Hand Surg Am. 2003;28(1):94-104.
6. Orbay JL, Touhami A. Current concepts in volar fixed-angle fixation of unstable distal radius fractures. Clin Orthop Relat Res. 2006;445:58-67.
7. Quadlbauer S, Pezzei C, Jurkowitsch J, et al. Early Rehabilitation of Distal Radius Fractures Stabilized by Volar Locking Plate: A Prospective Randomized Pilot Study. J Wrist Surg. 2017;6(2):102-112.
8. Kreder HJ, Agel J, McKee MD, et al.. A randomized, controlled trial of distal radius fractures with metaphyseal displacement but without joint incongruity: closed reduction and casting versus closed reduction, spanning external fixation, and optional percutaneous K-wires. J Orthop Trauma. 2006;20(2):115-121.
9. Willis AA, Kutsumi K, Zobitz ME, et al. 3rd. Internal fixation of dorsally displaced fractures of the distal part of the radius. A biomechanical analysis of volar plate fracture stability. J Bone Joint Surg Am. 2006;88(11):2411-2417.
10. Sobky K, Baldini T, Thomas K, et al.. Biomechanical comparison of different volar fracture fixation plates for distal radius fractures. Hand (N Y). 2008;3(2):96-101.
11. Dan MacLeod, Common Dimensions, Ergoweb® Learning Center, September 8, 2013,
12. Giddins G, Giddins H. Wrist and hand postures when falling and description of the upper limb falling reflex. Injury. 2021;52(4):869-876.
13. Johnston JD, McDonald MP, Kontulainen SA. Off-axis loads cause failure of the distal radius at lower magnitudes than axial loads: A side-to-side experimental study. J Orthop Res. 2020;38(8):1688-1692.
14. Salas C, Brantley JA, Clark J, et al. Damage in a Distal Radius Fracture Model Treated With Locked Volar Plating After Simulated Postoperative Loading. J Hand Surg Am. 2018;43(7):679.e1-679.e6.

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