SCIENTIFIC ARTICLE

Prospective Evaluation of Pronator Quadratus Repair Following Volar Plate Fixation of Distal Radius Fractures

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Purpose To evaluate the efficacy of pronator quadratus (PQ) repair after volar plating of distal radius fractures.

Methods All consecutive distal radius fractures treated operatively with a volar plate during a 1-year period were assigned to receive a repair of the PQ versus no repair. Surgical exposure, reduction, and postoperative rehabilitation were equivalent in both groups. Clinical outcomes with a minimum follow-up of 12 months were assessed via range of motion; grip strength; Disabilities of the Arm, Shoulder, and Hand (DASH) scores; and visual analog scale (VAS) scores.

Results A total of 60 consecutive distal radius fractures were treated operatively with a locking volar plate. Full follow-up data were available for 33 patients in the PQ repair group and 24 patients in the control group. At 12 months, the mean DASH score was 8 for the repair group and 5 for the control group. Range of motion at the wrist, grip strength, and VAS scores were also not significantly different between groups. In addition, we found no significant differences in any of the parameters at the 2-, 6-, or 12-week intervals, although we observed greater grip strength and wrist flexion in the repair group at 6 weeks. Reoperation was required for 4 patients in the repair group and 1 in the control group.

Conclusions Pronator quadratus repair after volar plating of a distal radius fractures did not significantly improve postoperative range of motion, grip strength, or DASH and VAS scores at 1 year. The rates of reoperation between groups were not significantly different. *(J Hand Surg 2013;38A:1678–1684. Copyright © 2013 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic II.

Key words Distal radius, fracture, outcome, pronator quadratus, volar plate.

Distal radius fractures are among the most common fractures of the skeleton and are estimated to account for 2.5% of all visits presenting to the emergency room.[1] As the treatment of this common injury has evolved, internal fixation with the volar locking plate has gained popularity as a method of contemporary surgical management.[2] Volar plate fixation has the advantages of obtaining articular

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fragment stability, a relatively low risk of tendon rupture, and early return to motion and functional strength.[3–16] However, to gain access to the fracture site through the volar approach, the pronator quadratus (PQ) muscle must be released and elevated. Controversy surrounds the merits of its subsequent repair, which theoretically augments postoperative clinical function, stability of the distal radioulnar joint, and soft tissue coverage over the hardware. Opponents of the PQ repair claim that the quality of the tissue often precludes a durable repair, and outcomes studies are universally good regardless. Although PQ repair was included in the initial technical descriptions of volar plating, at least 1 retrospective study has formally challenged this assertion.[9]

The purpose of this prospective trial was to evaluate the outcomes after volar plate fixation for distal radius fractures as a function of PQ repair. We assessed outcomes primarily through range of motion; grip strength; Disabilities of the Arm, Shoulder, and Hand (DASH) scores; and visual analog scale (VAS) scores. We secondarily compared the incidence of reoperation and postoperative complications such as tendon rupture, tendonitis, neuritis, malunion, and nonunion.

MATERIALS AND METHODS

We conducted a double-blinded, prospective, clinical trial from January 2011 to December 2011. Institutional review board permission was obtained, and all patients signed an informed consent. We assigned 60 consecutive distal radius fractures treated operatively with a volar plate into 1 of 2 groups. Repair of the PQ was performed in the study group, and no repair of the PQ was performed in the control group. The patients were blinded to their respective study group. For ease of facilitation, patients born in an odd birth year were assigned to the repair group, whereas those born in an even birth year were assigned to the control group. Patient demographics such as age, hand dominance, comorbidities, fracture severity, and presence of concurrent ulnar styloid fracture were recorded. The senior author (A.I.) classified all fractures in a blinded manner using the AO/ASIF classification system. Surgical exposure, reduction, and postoperative rehabilitation were similar in both groups. Two patients were lost to follow-up before 1 year and were excluded from the final analysis. One patient with an ipsilateral elbow fracture-dislocation was also excluded.

Surgical technique

A single orthopedic hand surgeon performed all surgical procedures. Either regional or general anesthesia was used in all cases with tourniquet control. The volar distal radius was exposed through a flexor carpi radialis approach. The PQ was released along its distal and radial borders and elevated in a subperiosteal fashion ulnarly, with care being taken not to violate the muscle or compromise its neurovascular pedicle inserting on the ulnar side from the interosseous membrane. All fractures were repaired with 1 of 2 variable-angle volar locking plates: a Medartis APTUS plate (Kennett Square, PA) or a Synthes 2.4 Variable-Angle LCP 2-column plate (Paoli, PA). In the repair group, repair of the PQ was performed over the plate with 4 to 5 interrupted figure-of-8 2-0 absorbable, synthetic, braided sutures to return the released edges of the PQ to the radial and distal borders of the radius. Repair of the muscle was achieved in all attempted cases, although we observed varying degrees of muscle injury. In the control group, the PQ was placed back to its anatomic position but was not repaired with sutures.

Postoperative management

Immediately after surgery, the patient was encouraged to elevate the hand and begin early and unrestricted finger motion. The postoperative soft dressing was maintained for 10 to 14 days until the first follow-up visit. At that visit, the dressings and sutures were removed, radiographs were taken, and therapy was started under the supervision of a certified hand therapist. A prefabricated orthosis was also applied for comfort and protection, but its use was optional. During weeks 2 through 6, an aggressive anti-edema protocol was initiated along with tendon gliding and range of motion exercises. At 6 weeks postoperatively, patients were reevaluated and advanced to progressive strengthening and resistance exercises upon evidence of sufficient interval healing by radiographs and clinical exam. In addition, use of the orthosis was discontinued. During reevaluation at 12 weeks postoperatively, patients were advanced to a work hardening program or discharged from therapy depending on occupational needs, and orthosis use was terminated. A final visit was performed 12 months postoperatively. An equivalent postoperative protocol was used for all patients irrespective of the study arm.

Assessment of outcomes

The primary outcome measure was the DASH score. Secondary outcome assessments included measurements of the VAS score, range of motion, and grip strength. An orthopedic nurse who was blinded to the study protocol obtained all of the outcome measurements during the follow-up visits. Wrist flexion, exten-

TABLE 1. Basic Demographic Information

Demographics	No Repair	PQ Repair	*P*
Patients, n	24	33	
Median age, y (mean [range])	62 (30–89)	55 (16–83)	
Mean age, y (mean [standard deviation])	60 (13.7)	51 (18.9)	.04
Male, %	25	27	1.00
Concurrent ulnar pin, n	2	1	.57
Concurrent CTR, n	2	2	1.00
Dominant hand injury, n	10	23	.06
Reoperations, n	1	4	.39
Associated ulna fracture			
No ulnar fracture, n	7	13	.26
Ulnar styloid fracture, n	13	18	
Ulnar neck fracture, n	4	1	
Ulnar base fracture, n	0	1	
AO classification			
A	2	8	.26
B	1	1	
C	21	24	

AO, Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation; CTR, carpal tunnel release.

sion, radial-ulnar deviation, and forearm rotation measurements were recorded with a goniometer. Grip strength was measured with a dynamometer (Jamar; Therapeutic Equipment, Clifton, NJ) with the elbow at 90° and the wrist in neutral rotation. These measurements were compared with the uninjured side and expressed as a percentage. All patients were assessed at 2, 6, 12, and 52 weeks after surgery. The senior surgeon also analyzed radiographs at the same intervals for evidence of fracture healing and maintenance of reduction.

Statistical analysis

We performed hypothesis testing using Fisher's exact test for categorical values and Student's *t*-test for continuous variables. Probability values for the outcomes measures were generated with an analysis of variance. Statistical significance was defined as $P < .05$.

RESULTS

A total of 57 patients were reviewed; PQ repair was performed in 33 subjects, and no repair was performed in 24 subjects. Table 1 lists basic demographics. Concurrent procedures were performed in 4 patients in the control group and in 3 patients in the repair group. Ulnar fracture was identified in 17 patients of the control group and in 20 patients of the repair group. Concurrent pinning of the ulna was indicated in 2 cases in the control group and 1 case in the repair group. Concurrent carpal tunnel release at the time of plating was indicated in 2 cases for each group. We also compared the groups with respect to fracture severity by the AO/ASIF classification system. The differences in fracture severity between the groups were not significant. Table 2 shows range of motion measurements at each time interval. Outcomes assessed at 2 weeks demonstrated no significant differences in mean DASH score, VAS score, grip strength, or range of motion. At 6 weeks, grip strength and flexion in the repair group were significantly greater than those of the control group, but all other variables were not significantly different. Similarly, we did not observe differences in any of the variables at 3 months or 1 year. At final follow-up, the mean DASH score was 8 for the repair group and 5 for the control group. In both groups, grip strength was 95% of the uninjured side, and VAS scores averaged below 0.5. The mean values of all variables demonstrated a stepwise improvement over the year as range of motion and grip strength consistently increased and DASH and VAS scores consistently decreased (Figs. 1–3).

TABLE 2. Range of Motion Measurements at Follow-Up Intervals

	2 wk		6 wk		3 mo		12 mo	
	PQ Repair	No Repair	PQ Repair	No Repair	PQ Repair	No Repair	PQ Repair	No Repair
Extension	29°	29°	59°	52°	74°	71°	83°	80°
Flexion	33°	39°	58°*	47°*	74°	69°	84°	81°
Pronation	77°	75°	83°	81°	86°	84°	84°	84°
Supination	67°	56°	78°	71°	85°	84°	88°	86°
Ulnar deviation	31°	14°	31°	26°	34°	38°	36°	35°
Radial deviation	7°	8°	16°	11°	18°	18°	19°	20°

*Statistically significant difference.

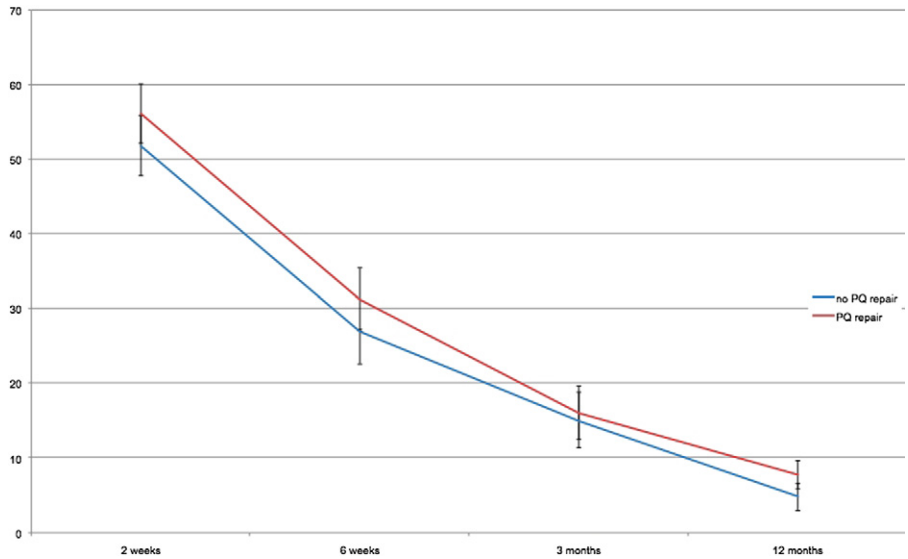

FIGURE 1: One-year trend of mean DASH scores after volar plate application for distal radius fractures in patients with and without repair of the PQ.

In the repair group, 1 patient developed extensor pollicis longus tenosynovitis and 3 patients presented with late symptoms of carpal tunnel syndrome; all 4 of these patients required reoperation for hardware removal or carpal tunnel release. In the control group, 1 case of extensor carpi radialis longus and brevis tenosynovitis required reoperation and plate removal. No cases of flexor tendonopathy, nonunion, hardware failure, infection, or acute carpal tunnel syndrome were observed.

DISCUSSION

The frequency of volar plating as a treatment for unstable distal radius fractures has increased in recent years.[2] Numerous studies have reported outcomes in the good to excellent range on patient-rated scoring systems and with a relatively low rate of complications.[4–9] For example, Gruber et al[5] described their prospective case series on 54 distal radius fractures treated with volar plating and noted an average DASH score of 5 at 2 years and 13 at 6 years, with no patients experiencing flexor tendonopathy. Similarly, Arora et al[6] prospectively compared operative and nonoperative management of unstable distal radius fractures in the elderly; in the 36 cases treated with open reduction internal fixation, the average DASH score at 12 months was 6, and 4 patients experienced flexor tendonopathy from prominent hardware. Our overall results were consistent with previous reports. We experienced no cases of nonunion, and all subjects healed in a radiographically acceptable position.

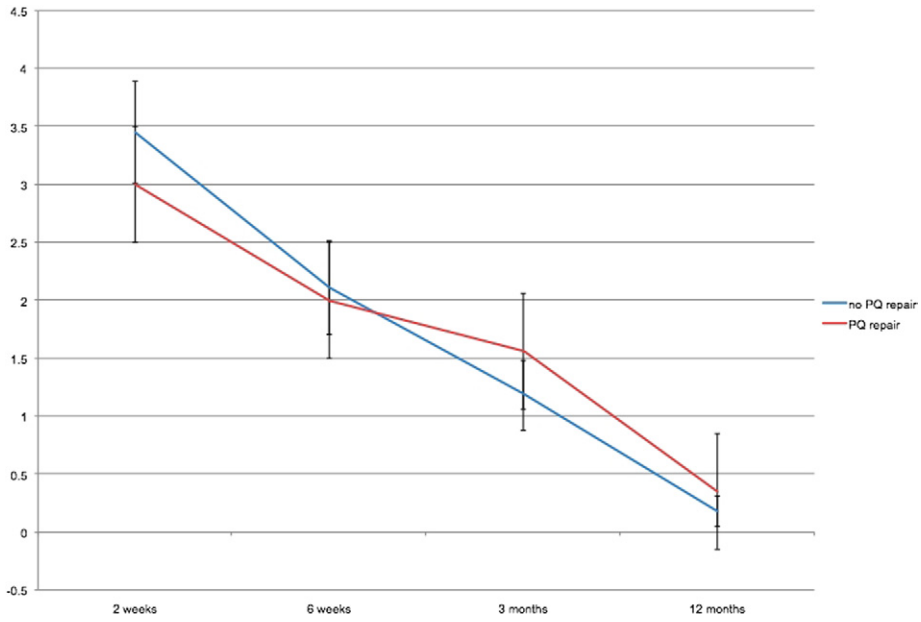

FIGURE 2: One-year trend of mean VAS scores after volar plate application for distal radius fractures in patients with and without repair of the PQ.

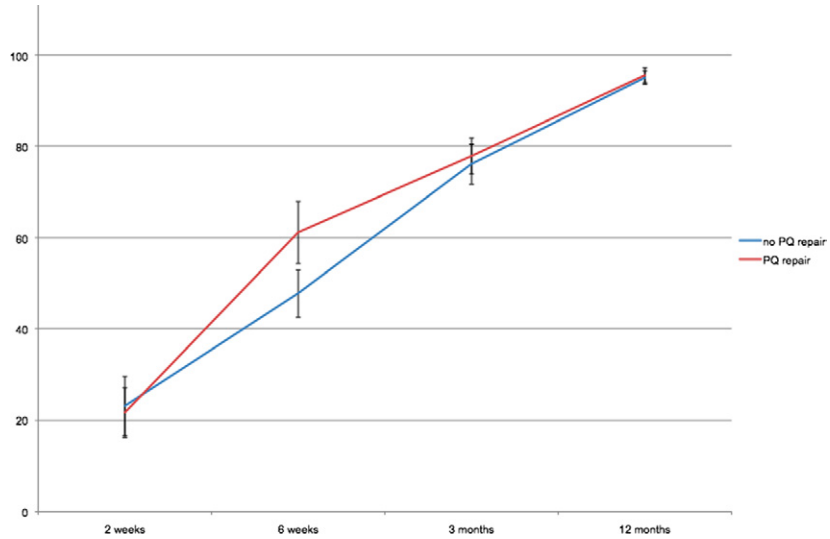

FIGURE 3: One-year trend of mean grip strength after volar plate application for distal radius fractures in patients with and without repair of the PQ.

Whether repair of the PQ is necessary after volar plating has been a topic of debate. Our study detected no significant differences between the PQ repair group versus control in mean grip strength, range of motion, DASH, or VAS scores for any of the study intervals within the first year. A study by Hershman et al[9] also examined outcomes of volar plating as a function of the PQ repair. In their retrospective review of 112 patients, 62 underwent repair of the PQ, and no significant differences were found in mean grip strength, range of motion, DASH, or VAS scores compared with the control group at 1 year. Four cases required reoperation: 2 for extensor pollicis longus rupture, 1 for intra-articular screw penetration, and 1 for flexor tendon irritation, which occurred in the repair group.

A recent survey of 608 hand surgeons reported that 83% routinely attempted a repair of the PQ after fixation.[17] This trend likely stems from the first technical descriptions of volar plating in which PQ repair was thought to augment wrist strength, distal radioulnar

joint stability, and soft tissue coverage over the plate.[3] Subsequently, several authors suggested that interposing the PQ between plate and flexor tendons may provide additional protection to the flexor tendons by reducing friction and attritional injury during tendon gliding.[3,18,19]

Conversely, opponents of PQ repair raise several questions with respect to its proposed advantages. First, no evidence exists to support any of the proposed benefits of PQ repair; and theoretical disadvantages such as over-tight repair, PQ space compartment syndrome, or iatrogenic radial artery injury have alternatively been proposed.[18,19] Second, some of the purported advantages of PQ repair can be explained, at least in part, by other factors. Placement of the locking plate proximal to the watershed line has been suggested as the key technical feature that reduces flexor tendon complications after plating.[10–16] White et al[16] reviewed their experience with 999 distal radius fractures treated via volar locking plates and found that 6 cases were complicated by 9 flexor tendon ruptures, and a prominent volar plate was observed in all cases. In addition, Soong et al[12] reported that flexor tendon rupture occurred in 3 of 73 cases, whereas Arora et al[14] described 9 cases of flexor tenosynovitis in 141 cases; in both of these studies, volar prominence of the plate was suggested as the causative factor although the PQ was routinely repaired. Brown and Lifchez[20] found that even though the PQ was repaired, the flexor pollicis longus tendon had eroded through muscle and was partially lacerated on a prominent plate at the time of revision surgery. A cadaveric study by Tanaka et al[21] similarly provided evidence to suggest that an improperly placed plate distal to the watershed line increases contact pressures at the plate–tendon interface and thus negates the anatomic advantages of the concave volar distal radius regardless of the interposed soft tissue.

Other purported benefits such as increased distal radioulnar joint stability and greater wrist strength are also less convincing arguments, in that the PQ is a relatively minor contributor to both of these functions.[22–25] Chirpaz-Cerbat et al[26] and Armangil et al[27] showed that 12% to 19% of pronation strength may be lost compared with the unaffected side after volar plating of the distal radius. However, a similar study by Huh et al[28] showed no differences at 1 year. In all of these studies, the PQ was released for exposure and subsequently repaired when possible. Alternatively, submuscular elevation of the PQ has been proposed to spare the dissection from the radial edge, but currently no biomechanical studies of postsurgical strength testing have been documented for this technique.[29]

The present study has limitations. One-year follow-up may not identify all of the potential complications such as tendon rupture, the need for hardware removal, or symptomatic posttraumatic arthritis. Although patients may present with late symptoms of flexor tendonopathy, many case studies have shown that tendon rupture and symptoms of impending rupture typically occur within 12 months after surgery.[6–9,11,13,15,16] Furthermore, we do not know whether the repairs were durable. However, a prospective trial by Swigart et al[17] assessed the durability of the PQ repair after volar plating and found it to be intact in 96% of cases at 3 months. In addition, in the present study, patients were not formally randomized, but rather assigned to groups via their birth year. The average age of the repair group was significantly less than the control group, which may have introduced bias, because a younger patient may be more critical of the outcome. Finally, pronation and supination strength testing was not performed.

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