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The effect of pronator quadratus repair on outcome after volar plating of distal radius fracture

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Abstract

Background: The incidence of fracture distal end of the radius is increasing with increasing life expectancy along with osteoporosis. Open reduction and volar plating has the biomechanical advantage of load bearing and buttressing function. Proposed advantages of pronator quadratus repair during volar plating of distal radius are the restoration of pronation strength, protection of flexor tendons from attrition or rupture and stabilization of the distal radio-ulnar joint whereas a tight repair may lead to the risk of ischemic contracture resulting into limited wrist pronation and supination. We aim to study the effects of pronator quadratus repair during volar plate fixation of distal radius fracture.

Methods: Traumatic extra-articular isolated closed, Gustilo grade I and II fracture of distal end radius with/without fracture ulna of adults presenting within 1 week were subjected to either repair or no repair group of pronator quadratus during volar plating of distal radius. They were operated by the same standard approach, subjected to same physiotherapy protocol and followed up regularly for at least one year post-operatively for outcome assessment.

Result: The cohort of patients in non-repair group (n = 19, mean age: 27.68 ± 8.38 years) and repair group (n = 13, mean age: 32.00 ± 15.58 years) have similar demographic and fracture characteristics. At 1 year, they had no significant difference in overall pain by visual analogue score (p = 0.989), functional outcome by disabilities of arm, shoulder and hand score (p = 0.178) and wrist range of motion (p > 0.05).

Conclusion: We conclude that there is no added advantage of pronator quadratus muscle repair during volar plating of distal radius. The functional outcome, overall pain and range of motion of wrist were not significantly different between them.

Keywords: Distal radius, functional outcome, pronator quadratus, muscle repair, fracture

1. Introduction

With increasing life expectancy along with osteoporosis, the prevalence of fracture distal end radius is increasing [1]. Though wide spectrum of treatment is available for the fracture from non-operative to operative methods as guided by patient profile, fracture personality, bone quality and surgeon's expertise; the ideal treatment can occasionally be conjectural [2]. Open reduction and plating can provide stable fixation which is essential for early mobilization and rapid regain of function [3]. Volar plate for distal radius being a load bearing implant, it has the advantage of load distribution in the subchondral bone [4]. Volar plating by conventional method requires elevating the pronator quadratus (PQ) muscle from its distal and lateral attachment with the radius.

Restoration of pronation strength, protection of flexor tendons from attrition or rupture and stabilization of the distal radio-ulnar joint are some of the claimed advantages of PQ repair. However, the quality of the tissue or buttonholing by bony spike may precludes a durable repair, rather a tight repair may lead to the risk of ischemic contracture of the pronator quadratus resulting into limited wrist pronation and supination [5]. Thus we proposed this study with the hypothesis that there is no difference in functional outcome with or without PQ repair after volar plating of distal radius.

2. Materials and Methods

We conducted a prospective comparative study to determine the effects of pronator quadratus

(PQ) repair on functional outcome in patients with distal radius fracture fixed with a volar plate. 36 consecutive and eligible patients presenting to a university based tertiary level hospital and academic institute, that provides trauma care to about 5.8 million populations, during the study period of one year were included by convenient sampling. The study was approved from the Institutional Review Committee (IRC) prior to the study and was carried out as per the declaration of Helsinki for experiments involving humans. Both the patients and the independent physiotherapist assessing the outcome of the intervention were blinded to the treatment group.

2.1 Inclusion Criteria

- Age ≥ 16 years and ≤ 60 years
- Closed / Gustilo grade I / II fracture
- Presenting within one week of injury
- Traumatic fractures of distal end radius with/without fracture of ulna

2.1.1 Exclusion Criteria

- Intra-articular fracture
- Multiple injury / polytrauma
- Any injury in the same limb
- Compromised soft tissue sleeve
- Neurovascular deficit

2.2 Sample Size Calculation

The conventional values for $Z_{\alpha/2} = 1.96$, power of the study ($Z_{1-\beta}$) = 0.84 were used. In a retrospective study, the mean DASH score for Pronator Quadratus repair group (μ_1) = 16.2 and mean for non-repair group (μ_2) = 11.2 at one year.^[6] Assuming population standard deviation (σ) in DASH score = 5 and using below formula for two independent means, the sample size was 16 in each group approx. (total 32).

$$n = \frac{2 (Z_{\alpha/2} + Z_{1-\beta})^2}{\left(\frac{\mu_1 - \mu_2}{\sigma} \right)^2}$$

Assuming 10% loss to follow up, we recruited total of 36 consecutive patients.

2.3 Group Allocation

One of the authors enrolled the eligible and willing patients after through counselling regarding procedure detail to obtain informed written consent. For ease of case facilitation, patients born in an even birth year were assigned to the non-repair group (n = 19), whereas those born in an odd birth year were assigned to the repair group (n = 17) and the same was mentioned on patient's record file. The patients were blinded to their respective study group.

2.4 Operative Intervention

After thorough clinico-radiological examination, every patient was assessed for underlying exclusion criteria (if any) including fitness for surgery.

Similar type, dose and duration of perioperative antibiotics were administered in both the groups. All the cases were operated under regional or general anesthesia with patient in supine position with ipsilateral arm abducted and forearm supinated on the side table, using modified Henry approach to expose volar distal radius. Tourniquet was inflated at appropriate pressure in all cases. In the PQ repair group, the muscle was elevated along its distal and radial border to

reflect subperiosteally towards ulna preserving its neurovascular pedicle inserting on its ulnar side from interosseous muscle and without violating the integrity of the muscle. Appropriate length volar non-locking/locking distal radius plate made from 316 L stainless steel (Greens Surgicals Pvt. Ltd, India) was used to fix the fracture after open reduction. The fracture reduction and implant placement were verified under image intensifier in all the cases. 3 to 4 interrupted sutures using 2-0 absorbable, synthetic, braided suture were used to attempt the repair of PQ muscle in the repair group^[7] while it was simply replaced back to its anatomical position in the non-repair group.

In 2 cases out of 17 among the repair group, we failed to repair PQ due to traumatic contusion and/or poor tissue quality and thus were included in non-repair group during analysis. (Fig. 1) However, we were able to repair PQ muscle even in some cases with button-holing of the muscle by fracture spike. (Fig. 2a – 2d).



Fig 1: Difficult Pronator Quadratus repair



Fig 2a: Bony spike buttonholing the muscle



Fig 2b: Fracture reduction under vision



Fig 2c: Proximal & distal muscle flap before repair



Fig 2d: After repair of the muscle

All the cases were operated at a single institute by a single orthopedic trauma surgeon having adequate years of clinical experience. Postoperative drain was used for none of the cases. The skin was closed with staples. Below-elbow posterior POP slab was applied for immobilization and soft tissue healing.

2.5 Postoperative Management

Early active finger mobilization and limb elevation were encouraged while in below-elbow slab for comfort and protection along with anti-edema measures. At 2 weeks, sutures were removed, assessment for any signs/symptoms of surgical site infection (SSI) was done, VAS score for pain and DASH functional score were calculated. The slab was then optional depending upon quality of bone, stability of fixation, patient's compliance and surgeon's confidence. Hand physiotherapy was started under the supervision of a certified therapist with tendon gliding and range of motion exercises, progressively to strengthening and resistance exercises depending upon clinico-radiological healing of fracture. Patients were again followed up at 6 weeks, 12 weeks, 24 weeks and 52 weeks for functional outcome assessment (DASH score), pain at fracture site (VAS score), range of motion (ROM) of wrist/forearm and clinico-radiological union of fracture and associated complications (if any).

2.6 Data Extraction

Patient's demographic profile and injury characteristics including age, fracture personality, side/dominant side, mechanism, associated ulnar fracture, injury to presentation interval and presentation to surgery interval were recorded by the surgeon as per pro forma for all the patients. A separate supplementary pro forma (not mentioning the intervention group, but only code) was used by the blinded physiotherapist in successive follow up of each patient for outcome assessment.

2.7 Outcome Measures

The primary outcome of our study was the functional outcome (DASH score) whereas the secondary outcomes were pain at fracture site (VAS score), ROM of wrist (measured clinically by a goniometer and expressed as % of opposite normal side), clinical and radiological healing^[8] of fracture and associated complication(s) at final follow up of one year. All outcomes were assessed by an independent physiotherapist instructed in standardized testing and who was blinded to the study protocol. Complication was considered when primary reduction was lost or implant loosened / broken / produced irritation, or clinical evidence of flexor tendon (FPL) irritation / rupture, or antibiotics and/or debridement was necessary to treat a SSI, or bone grafting needed for delayed union/nonunion.

2.8 Statistical Analysis

Statistical analysis was performed with use of Statistical Product and Service Solutions (SPSS version 20.0, IBM Corp.). The data was checked for normality using Kolmogorov–Smirnov test (KS test). Mean and standard deviation calculation for the descriptive numerical variables and frequency tabulation of categorical variables were done for both the groups to verify the matching of the cohorts. Magnitude and significance of the difference were measured and tested assuming $p \leq 0.05$ (two sided) as significant using independent t-test for continuous variables and Fisher's exact test for categorical variables. Subgroup analysis and adjusted analysis were not done.

3. Results

2 patients out of 21 in no-repair group (at 12 weeks and 14 weeks) and 2 patients out of 15 in repair group (at 11 weeks and 14 weeks) were lost to follow up and thus 19 patients and 13 patients respectively (who completed 12 months follow up) were included in the final analysis.

The overall mean age of the patients included in our study was 29.44 ± 11.80 years. (range: 16– 60 years, Median = 29.5 years, Q1=18.25 years and Q3=34.75 years). The demographics and injury characteristics / fracture personality were similar between the two groups of cohorts with respect to all the independent variables considered. ($p > 0.05$) In our study, we found predominantly males with right sided (also dominant sided) sustained fracture which were mostly closed, simple fractures of distal radius without ulnar fracture. The most common modes of injury were Motor Vehicle Accidents (MVA) and slip on ground. They usually presented to us within 6 hours of injury and most of them get operated within 24 to 48 hours of presentation. ($p > 0.05$) (Table 1)

Table 1: Demographics and Injury Characteristics

Variables		No Repair Group (n = 19)	Repair Group (n = 13)	P value
Mean Age (Yrs.) (mean ± SD):		27.68 ± 8.38	32.00 ± 15.58	0.318
Gender (n):	M: F	11: 8	9: 4	0.713
Type of Fracture (n):	Closed	14	12	0.388
	Gustilo Grade I	4	1	
	Gustilo Grade II	1	0	
AO Classification ^[9] (n):	2.R.3.A	12	7	0.864
	2.R.3.B	6	5	
	2.R.3.C	1	1	
Side (n):	Right	13	9	1.000
	Left	6	4	
Dominant Side (n):	Yes	14	6	0.150
	No	5	7	
Mechanism of Injury (n):	MVA	7	4	0.350
	Slip on Ground	8	4	
	Fall from Height	4	3	
	Physical assault	0	2	
Fracture of Ulna (n):	Present	4	6	0.244
	Absent	15	7	
Injury to Presentation (n):	≤ 6 hours	11	7	0.962
	> 6 to ≤ 12 hours	5	4	
	> 12 hours	3	2	
Presentation to Surgery (n):	≤ 24 hours	5	3	0.851
	> 24 to ≤ 48 hours	9	7	
	> 48 hours	5	3	

MVA: Motor Vehicle Accident

At 2 weeks, 3 cases in no-repair group (2 stitch abscess and 1 superficial abscess) and 2 cases in repair group (1 stitch abscess and 1 superficial abscess) had SSI but all of them healed with regular dressing and a course of oral antibiotics, without any further sequelae by next 2 weeks. At 6 weeks, 30 out of 32 cases (94%) had union on x-ray, as per radiological union score for tibia (RUST) now generalized for other fractures as well [8], while the remaining 2 cases (repair group) were also united by 12 weeks follow-up. However, we did not compare the grip strength between the injured and uninjured side.

We found slightly better functional outcome in PQ repair group (lower DASH score) at 2 weeks, 6 weeks, 12 weeks, 24 weeks and 52 weeks follow up though not significant at any point of time (p values = 0.198, 0.495, 0.205, 0.159 and 0.178 respectively). (Fig. 3) Similarly, patients reported overall lower fracture site pain in repair group (lower VAS score) at each of these follow up, but was not significant. (p values = 0.187, 0.112, 0.744, 0.326 and 0.989 respectively). (Fig. 4) At final follow up of minimum 1 year (range: 12 months to 16 months), we assessed range of motion (ROM) of the wrist and expressed as percentage (%) of opposite normal side and found no significant difference in ROM of wrist / forearm between the groups. (p > 0.05 for all) (Table 2)

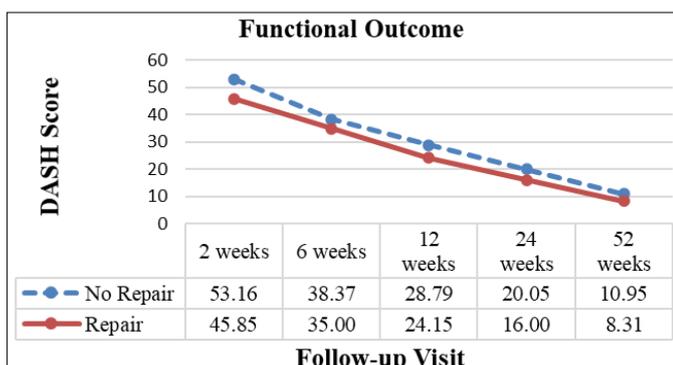


Fig 3: Comparison of Functional Outcome (DASH score)

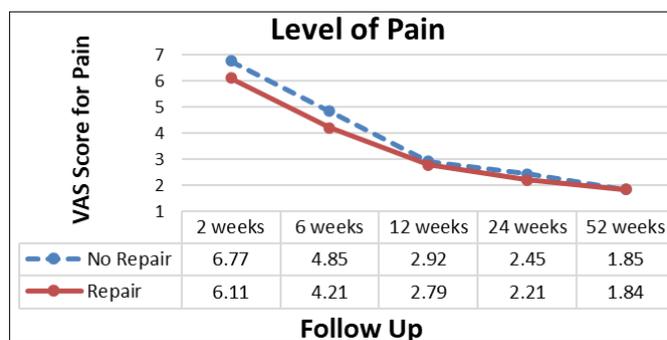


Fig 4: Comparison of Fracture site pain (VAS score)

Table 2: Range of Motion (ROM)* (mean ± SD)

Variables	No Repair Group (n=19)	Repair Group (n=13)	P value
Dorsiflexion:	83.16 ± 3.35	83.69 ± 5.25	0.727
Palmarflexion:	87.05 ± 4.58	85.00 ± 3.83	0.194
Radial Deviation:	82.68 ± 3.62	83.46 ± 3.95	0.570
Ulnar Deviation:	83.95 ± 3.76	83.85 ± 3.51	0.939
Supination:	86.00 ± 7.65	83.23 ± 7.91	0.329
Pronation:	86.89 ± 7.59	82.69 ± 6.41	0.112

*Expressed as percentage (%) of opposite normal side; Significant at p < 0.05

4. Discussion

We studied the effects of repair of Pronator Quadratus during volar plate fixation for extra-articular distal radius fracture. The most common modes of injury were MVA most likely for younger patients and slip on ground for elderly as an insufficiency fractures, characteristics of the classical bimodal distribution of distal end radius fractures. Though we had only one case of Gustilo grade II open fracture (in non-repair group) and five cases of Gustilo grade I open fractures, we did not study the pre-hospital management and the antibiotics treatment received by them.

Although suture anchor repair was the strongest repair in a biomechanical cadaveric study, simple interrupted suture could hold the repair if the wrist was immobilized.[7] We

repaired the pronator quadratus muscle by simple interrupted suture and forearm was immobilized. In two cases, repair of PQ was not possible due to button-holing of the muscle by fracture spike and/or poor tissue quality, however difficulty might be also due to prominent hardware or traumatic disruption specially in elderly. Such incompetent or failed repair might spuriously reflect similar outcome between the groups and no advantage of PQ repair [10]. However, a partial split and distal transfer of pronator quadratus [11], elevating a part of brachioradialis insertion [12] as well as splitting brachioradialis and sparing PQ to cover distal part of the plate had been described [13]. To overcome these problems and to avoid muscle atrophy, scarring or dysfunction because of suturing, PQ sparing has been suggested during distal radius plating. [14] However, the radiological outcome reported was similar between PQ sparing approach with plate sliding underneath the muscle and conventional PQ elevating approach during volar plating of distal radius but the study did not mention the clinical outcomes [15]. Meta-analysis has shown better patient satisfaction and improved radial inclination with the minimally invasive plate osteosynthesis (MIPO) compared to the conventional technique, although both were effective [16].

We found a gradual improvement in DASH score over time in both the groups but was not significant at any point of time. The functional outcome (DASH score), overall pain (VAS score) and range of motion (ROM) of wrist at 1 year between the groups were not significantly different in our study, which was consistent with prior studies [5, 6, 17] however there might be lesser pain, at least in early post-operative period in PQ repaired cases but similar at long term [18, 19]. Additionally, the ROM at 4 weeks (p=0.03) and grip strength at 12 weeks (p=0.01) was significantly better in the PQ repair group in a study [18].

Moreover, no functional difference was noted between a complete repair of PQ and an incomplete repair of PQ muscle during volar plate fixation of distal radius. [20] However, study had reported a statistically significant loss of forearm

pronation strength after plate fixation of the distal radius but the possible causes for such difference like initial trauma, iatrogenic damage during surgery, insufficiency of suturing in traumatized muscle, change in muscle tension were not studied [21].

Despite a reported incidence of flexor pollicis longus (FPL) tendon rupture between 1.9% to 12% after volar plate fixation [22], we did not find tendon rupture or irritation due prominent hardware in our study. Although plate mal-positioning, prominent screws, intraoperative trauma or temporary traction neurapraxia to nerve supply to FPL were also blamed for the rupture [22], some study claimed that PQ plate coverage may not adequately protect tendons [23], while others recommend PQ repair to protect flexor tendon irritation or rupture. [24] Ultrasound evaluation of the PQ repair after volar plating of distal radius has shown that the outward-return running suture with a 3-0 single strand thread can significantly prevent FPL attrition, rupture and clinical tenosynovitis [25]. However, a tenosynovitis may progress to tendon rupture in the presence of metalwork [26].

Despite reported cases of carpal tunnel syndrome (CTS) along with incidence of complex regional pain syndrome (CRPS) of 1.9%, prominent/symptomatic hardware of 1.9%, contracture of fingers/wrist, radio-ulnar synostosis; such complications were not seen in any patients among the two groups in our study [27].

All the cases were operated by the same orthopedic trauma surgeon at a single center, where the patients were blinded to their respective group and the outcome assessment was done by the single blinded physiotherapist instructed in standardized testing which were the strengths of our study. However, unequal sample size, no proper randomization, no radiological study of the distal radial parameters and no assessment of grip strength were the limitations of our study. Despite these limitations, this study had attempted to provide evidence to support our hypothesis.

Case Illustration: (Fig. 5a – 5j)



Fig 5a: Pre-operative x-ray



Fig 5b: Post-operative x-ray



Fig 5c: 6 Weeks follow-up x-ray



Fig 5d: 3 Months follow-up x-ray

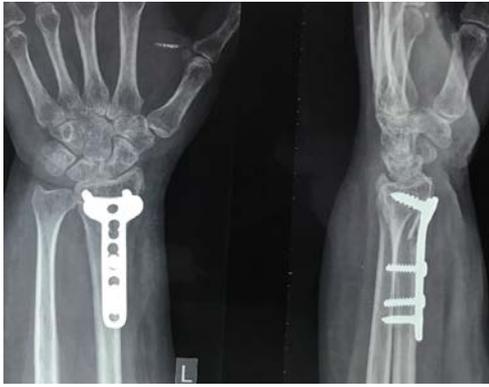


Fig 5e: 6 Months follow-up x-ray



Fig 5f: 9 Months follow-up x-ray



Fig 5g: 12 Months follow-up x-ray



Fig 5h: After implant removal at 12 months



Fig 5i: Wrist dorsiflexion at 12 months



Fig 5j: Wrist palmar flexion at 12 months

5. Conclusion

We conclude that there is no difference in functional outcome, overall pain and range of motion between repair and no repair of pronator quadratus muscle during volar plating for fracture distal end of radius.

6. Conflict of Interest: None

7. Financial disclosure: None

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