

Do We Need to Suture the Pronator Quadratus Muscle When We do Open Reduction and Internal Fixation for Fracture of the Distal Radius

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Abstract

Background: For fracture of the distal radius, open reduction and internal fixation are often used for treatment. In the process of open reduction and internal fixation, it is often necessary to open the pronator quadratus muscle to achieve sufficient exposure. So it's important to know if it's necessary to suture the pronator quadratus muscle. Purpose: To see if suturing the pronator quadratus during the treatment of fracture of the distal radius would improve limb function.

Methods: 126 patients were selected for our study. These patients had open reduction and internal fixation. During the procedure, the pronator quadratus is cut open to allow the plate to be placed. Before the surgery was completed, the pronator quadratus muscles of these patients were stitched together. After the fracture healed, the patients underwent surgery to remove the internal fixation. These patients received wrist function scores prior to removal of internal fixation. The healing of the pronator quadratus was investigated during surgery. These patients were grouped according to the healing of the pronator quadratus. Functional scores were compared between the two groups

Results: 23 patients were considered to have muscle healing during surgery. However, in these patients, the PQ muscles were obviously atrophic, with scar hyperplasia and fibrosis. The muscle fibers were loose and thin, and the number was reduced. At the same time, the remaining muscle fibers have different degrees of adhesion with radial carpal flexor muscles, steel plates and interosseous membrane. According to the intraoperative situation, 23 patients were included in group A and 103 patients were included in group B. There were no statistically significant differences in age and fracture type between group A and group B. At the same time, there were no statistically significant differences in isokinetic forearm pronation strength and clinical outcomes including grip strength, wrist ROM, and PRWE scores between the two groups.

Conclusions: this study demonstrates that whether the PQ muscle healing or not does not affect the outcomes of volar plating for distal radius fractures in terms of isokinetic forearm rotation strength, grip strength, wrist ROM, and PRWE scores.

Introduction

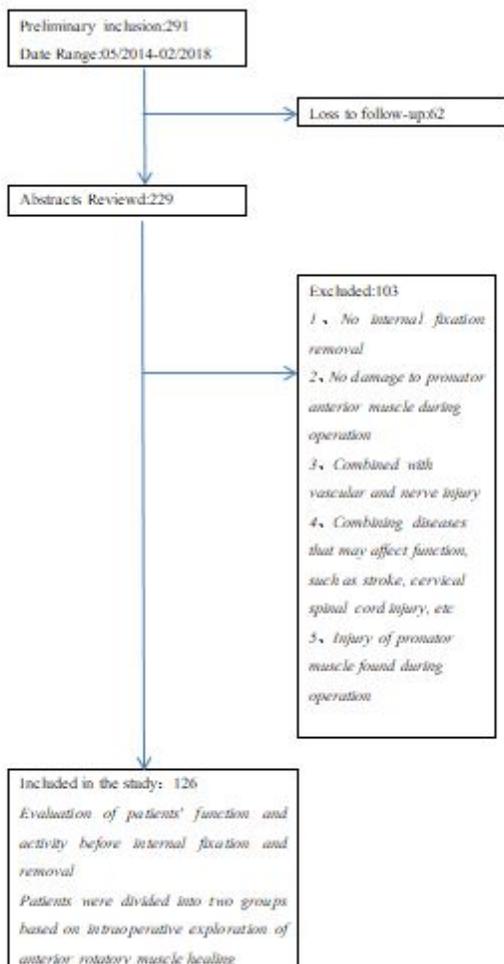
Pronator quadratus muscle (PQ muscle) is a quadrilateral muscle located on the palmar side of the distal forearm, which is attached to the interosseous membrane of radius, ulna and forearm. It is composed of the shallow head and the deep head. The deep head is thicker than the shallow head. The average volume of the whole muscle is 5.5cm x 5.0cm x 1.0cm. The anterior interosseous artery and the anterior interosseous nerve are the main arteries and nerves of pronator. The main function of pronator is to pronate the forearm[1].

In the treatment of distal radius fractures with open reduction and internal fixation with steel plates, this muscle is often cut open[2]. Whether the PQ muscle needs to be repaired is still controversial[3\4]. At present, most scholars adopt the method of prospective research. These studies mainly divided patients

into two groups, one group had their PQ muscles repaired and the other group did not. The efficacy of the two groups was then compared[3-6]. However, the question of whether the anterior rotator cuff healed after repair was not included in the study. The effect of PQ muscle healing on function remains unclear. This may be because most patients do not required to be removed for internal fixation[7]. We performed the removal of internal fixation in more than 100 patients with distal radius fractures who underwent open reduction and plate internal fixation. Groups were divided according to the healing of the PQ muscle found during the operation. The patient's function was evaluated before the removal of internal fixation. The purpose of this study is to investigate the effect of PQ muscle healing on patients' function.

Materials And Methods

This is a retrospective study between May 2014 and February 2018. A total of 126 patients with distal radius fractures who underwent open reduction and plate internal fixation in our hospital were included in the study. Patients with distal radius fractures who met the inclusion criteria (age more than 18 years) were included in the study. The radiographs of all initial fractures were reviewed and fractures were classified according to the AO classification as type A (extra-articular fractures), B (partial articular fractures), or C (complex articular fractures) and their subtypes. The Hospital Ethics Committee approved the current study (Table 1).



All surgical procedures were performed by the 2 principal investigators. The chief surgeon, the corresponding author of this paper, has more than 20 years' experience in surgery and is qualified for this operation. The palmar Herry approach was adopted in all surgeries. Part of the transverse carpal ligament was cut open and the radial artery and flexor tendon were retracted to expose the PQ muscle. The PQ muscle was severed from the radial stop of the radius at 2-3 mm, and then detached above the periosteum. Finally the muscle is pulled over to the ulnar side to fully expose the metacarpal surface of the distal radius. Fractures were fixed using a volar locking plate system (VA-LCP Distal Radius Plate 2.4 mm; Synthes, Oberdorf, Switzerland). The PQ muscle was repaired to the insertion as close as possible using absorbable sutures (Ethicon, Johnson & Johnson, USA) with the forearm in supination at the end of the operation.

Patients were seen in clinic 3–5 days postoperatively to answer questions and examine the surgical incision. They were subsequently followed at 3, 6 weeks, 3 and 6 months. Followed by passive wrist motion below 90° of forward flexion under the supervision of a therapist for the first 3 weeks. At 6 weeks, the patients were progressed to full active motion as tolerated. After X-ray confirmation of fracture healing, the patients were permitted to resume full activities and weight-bearing.

The removal of the internal fixation would be performed one year after the fracture has healed. Whether to remove the internal fixation depends mainly on the patient. Most patients do not remove the internal fixation due to local pain symptoms or other complications. The main reason for the removal of internal fixation in these patients is that they do not want to have a foreign body. Prior to the removal of the internal fixation, the patient's function and wrist motion were recorded. The PRWE score is used to evaluate a patient's functioning. Herry's approach to the original surgical incision was used for the removal of internal fixation. The soft tissue was separated between the flexor carpi radialis and the radial artery to expose the PQ muscle. Then determine whether the PQ muscle is healing (Figure 1). Unhealed patients have almost no muscle fibers and complete muscle scarring (Figure 2). The PQ muscles of the healing patients were significantly atrophic with scar hyperplasia and fibrosis. The muscle fibers of the PQ muscle became loose and thin, and the number decreases. When we could not see the fibers of the PQ muscle we judge that the PQ muscle in this patient was not healing.

Statistical Analysis

We divided patients into A group (healed group) and B group (unhealed group) according to whether PQ muscles healed after the removal of the internal fixation. The 2 groups were compared in terms of demographic data, isokinetic forearm rotation strength, and clinical outcomes including grip strength, wrist ROM, and PRWE scores [8] before the removal of the internal fixation. At a constant speed in the ROM to measure the isokinetic muscle strength [9]. The measurement of isokinetic muscle strength of forearm rotation is an effective and reliable method to evaluate muscle function [10]. We used Biodex System 4 (Biodex Co., Shirley, NY, USA) to test at 90°/s. We first assessed the uninjured side and then the injured side. We had the patient do 10 repetitions of isokinetic motion to measure peak torque (Nm, the

highest torque measured) and total work (J, the greatest amount of work performed). We use the Exacta electronic dynamometer (nc70142-hkp, B & L engineering, USA) to measure the grip strength. When measuring, bend the elbow 90 degrees, and rotate the forearm in neutral direction. The result is in kilogram[11]. Two doctors measured the patient's wrist ROM with a standard goniometer and they do not know the result of each other's measurement. We also requested the patients to complete the PRWE questionnaire[8] which evaluates general disabilities related to the upper extremity. The PRWE scores range from 0 to 100, where higher scores indicate less upper extremity disability. We compared categorical data using the chi-square test and continuous data using the t-test.

Results

We found that the PQ muscle of most patients was replaced by scar, although the pronator muscle was sutured. 23 patients were considered to have muscle healing during surgery. However, in these patients, the PQ muscles were obviously atrophic, with scar hyperplasia and fibrosis. The muscle fibers were loose and thin, and the number was reduced. At the same time, the remaining muscle fibers have different degrees of adhesion with radial carpal flexor muscles, steel plates and interosseous membrane. According to the intraoperative situation, 23 patients were included in group A and 103 patients were included in group B. There were no statistically significant differences in age and fracture type between group A and group B. At the same time, there were no statistically significant differences in isokinetic forearm pronation strength and clinical outcomes including grip strength, wrist ROM, and PRWE scores between the two groups (Table 2).

Table 1
Demographic Data and Clinical Outcomes

Variable	Group A (n = 23)	Group B (n = 103)	Statistic T-value /c ² -value	p-value
Gender(Male / female)	12/11	61/42	0.38	0.54
Age (yr)	53.65±8.63	55.85±7.56	1.23	0.22
Affected hand(dominant /non-dominant)	16/7	51/52	3.03	0.08
Fracture type			0.77	0.679
A	9	17		
B	3	6		
C	29	80		
Isokinetic strength (%)*				
Peak pronation strength	79.23±21.17	80.19±19.27	0.21	0.83
Total pronation work	73.16±31.65	72.36±27.39	0.12	0.90
Peak supination strength	78.92±27.16	79.25±28.36	0.05	0.96
Total supination work	74.19±33.02	73.53±30.26	0.09	0.93
Grip strength (%)	71.36±19.86	72.51±23.52	0.22	0.83
Wrist range of motion (°)				
Flexion	53.33±9.55	52.27±10.69	0.44	0.66
Extension	68.75±11.16	63.33±15.52	1.58	0.12
Pronation	79.36±10.73	77.55±11.76	0.68	0.50
Supination	72.69±13.12	73.67±9.72	0.41	0.68
PRWE score	16.33±15.69	17.56±17.55	0.31	0.76

Values are presented as mean ± SD.

PRWE: Patient-Rated Wrist Evaluation.

*For isokinetic strength, values after adjusting for hand dominance are presented in the parentheses

Discussion

In recent years, the use of volar locking plate to treat distal radius fractures has become increasingly popular. Several studies have reported that patients get better functional scores after surgery with fewer

complications[4-6]. However, it is controversial whether the anterior rotator cuff should be repaired intraoperatively.

Although the patient received the repair of pronator during the operation, the pronator strength of the patient was still affected[12]. This may be related to factors such as original muscle injury, loose suture, muscle tension change and muscle atrophy. Through a clinical case observation study, Swigart confirmed that the failure rate of PQ muscle repair was 4%, with 1 failure in 24 patients. And their study confirmed that the presence of preoperative injury to the PQ muscle was not associated with surgical failure[13]. In their research, radiopaque hemoclips were attached to each side of the PQ repair. After the surgery, the patient underwent X-ray reexamination to see if the radiopaque hemoclips had shifted. However, in our study, we found that the incidence of repair success was not as high as previously reported by direct observation. The normal anatomical structure of PQ muscle is the basis of its function[14]. Our study observed that after suture of the anterior rotatory muscles, the muscles were all scarred, significantly atrophic, and adhered to the surrounding tissues. Muscle function is largely lost because its anatomy does not return to normal. This may be related to the following factors. After the muscle is severed, the blood supply to the muscle from the radial artery is destroyed, so the repair of the muscle is affected. The anterior rotator cuff is a brittle piece of muscle that is difficult to sew together. This muscle is often torn up after being sewn up. Especially after the placement of steel plate, the tension of local soft tissue will increase obviously, that causes the muscles to be hard to pull together. In addition, PQ muscle is prone to adhesion with surrounding tissues during the healing process, which will affect its function. Because fractures take time to heal, the affected limb is not allowed to be loaded until the fracture heals. When the fracture heals, the anterior rotatory muscle often has a disuse atrophy.

Our study also observed that the healing of the pronator muscle did not lead to better function in patients. There were no significant differences in functional scores, activity levels, and strength between the two groups. Since we have excluded patients with anterior rotatory muscle injury before the study, we do not believe that primary injury is a common cause of postoperative loss of muscle function. Nho[15] also confirmed that the PQ muscle was atrophic during the removal of internal fixation, and that the muscle width was independent of the final clinical functional outcome, suggesting that the PQ muscle may be functionally lost after suture. Because pronator teres is the main muscle of forearm pronation[17], the loss of pronator teres can be compensated by pronator teres, so that forearm rotation can be preserved. Many studies also believe that suture of pronator anterior muscle may not give patients better function and mobility[18-20].

Conclusion

There are several limitations to the present study. The number of cases included in this study was small. We also did not evaluate the possible effect of combined injuries around the wrist on rotational function of the wrist. All these need to be further improved in our future research.

In summary, this study demonstrates that whether the PQ muscle healing or not does not affect the outcomes of volar plating for distal radius fractures in terms of isokinetic forearm rotation strength, grip strength, wrist ROM, and PRWE scores. The results of this study support our current practice of incision of PQ muscle. Most surgeons expose fractures by incision of PQ muscle, which shows that PQ muscle release repair is not necessary to improve forearm function.

Abbreviations

PQ muscle: Pronator quadratus muscle;PRWE: Patient-Rated Wrist Evaluation

Declarations

Acknowledgements

Not applicable.

Author's contributions

Study design: Fang. Study conduct: Lin. Data interpretation: Shi. Drafting manuscript: Liu. Dai takes responsibility for the integrity of the data analysis. KK takes responsibility for the integrity of the data analysis.

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Availability of data and materials

The datasets used and/or analyzed during current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the institutional review board at The Second Affiliated Hospital of Fujian Medical University (#2020.183). Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflict of interest.

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Figures



Figure 1

a The PQ muscle was sutured during the operation b The PQ muscle was proved to have healed during the plate removal operation

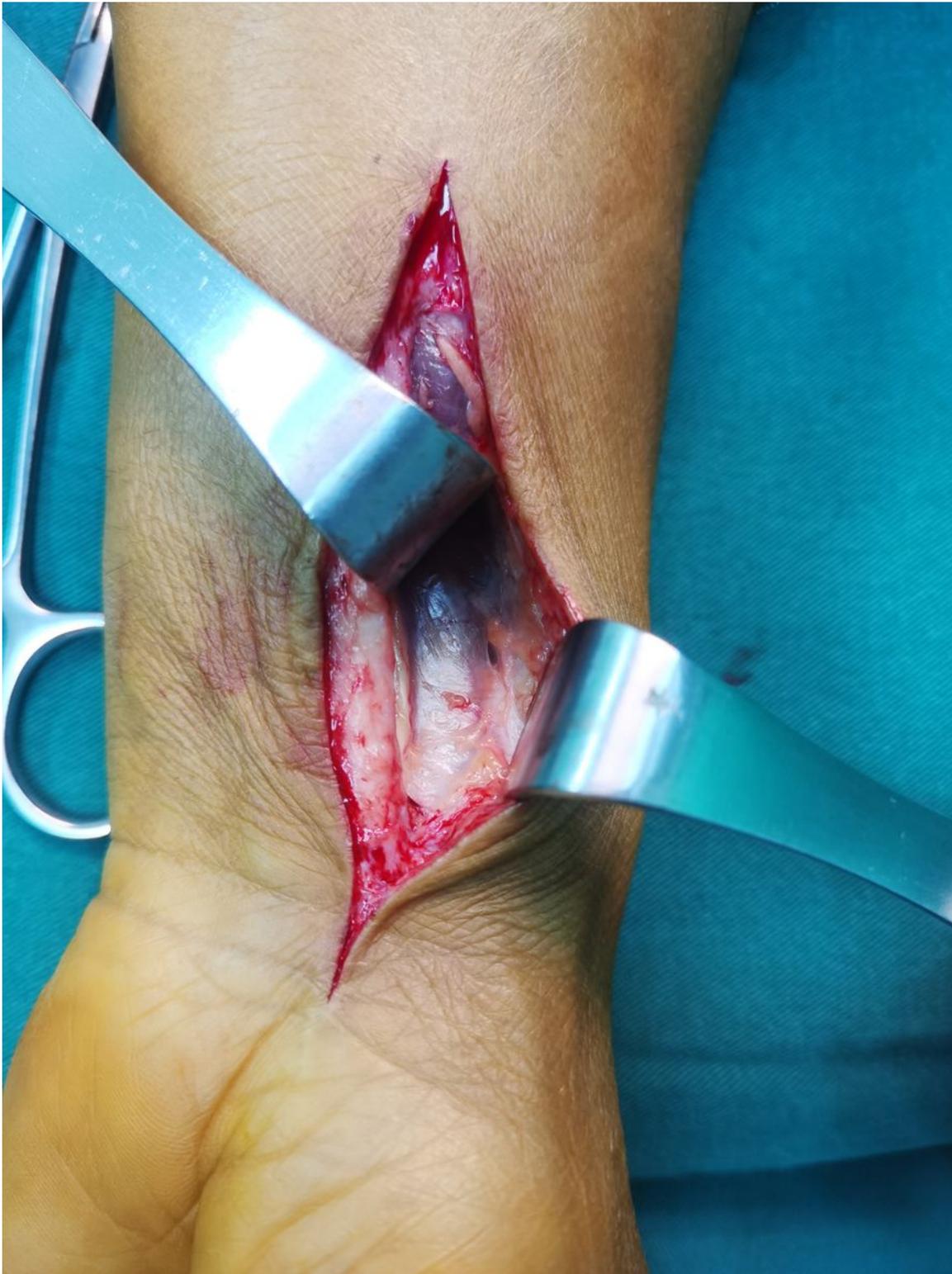


Figure 2

a The PQ muscle was proved not to heal during the plate removal operation b Pathological examination showed scar formation and no muscle fiber was found.

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