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ORIGINAL STUDY

Analysis of soft-tissue complications of volar plate fixation for managing distal radius fractures and clinical effect while preserving pronator quadratus

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The aim of the study was to analysis soft-tissue complications of volar plate fixation and it's prevention strategies along with exploring clinical effects of preserving pronator quadratus (PQ) muscle.

From February 2011 to February 2013, sixty-five patients with distal radius fracture underwent open reduction and internal fixation with the volar locking palmar plates. The group with preserving PQ involved 30 patients and group with PQ repair involved 35 patients. Surgeons must took great care of not letting drill pierce dorsal cortical bone rapidly and dorsal carpal tangential fluoroscopy was also taken in addition to lateral fluoroscopy to get accurate screw length. Volar plate must be placed not go beyond the watershed region of distal radius. The wrist pain, forearm range of motion, grip strength, wrist functional recovery score, X-ray and CT imaging were followed-up after surgery. Two groups were compared for Clinical efficacy.

The minimum follow-up for the whole cohort was one year. The relevant post operative data were collected after 2 weeks, 6 weeks, 3 and 12 month respectively. Fractures healing after postoperative 3 months are significant in X -ray and CT imaging. Fixation position and stability were good, but each group had one case with a screw piercing the dorsal cortical. The differences between the two groups were significant regarding the wrist pain, forearm range of motion, grip and strength at 2 and 6 weeks after operation, but not significant at 3 and 12 month after operation. The differences between the two groups were also significant regarding wrist functional scores at 6 weeks, but not significant at 3 and 12 month after operation.

Drilling the dorsal cortical bone gently and accurate screws length can avoid extensor tendon injury. Dorsal carpal tangential fluoroscopy is a useful supplement for accurate screws length besides lateral fluoroscopy. Volar plate's position not go beyond the watershed region of distal radius is the key factor in reducing the flexor tendon injury and preservation of the PQ muscle can also prevent the flexor tendon injury, yield better early wrist function and shorten rehabilitation time.

Keywords : soft-tissue complications ; distal radius fracture ; open reduction ; palmar plate ; Pronator Quadratus (PQ) ; Pronator Quadratus preservation.

INTRODUCTION

Distal radius fracture is a common emergency fracture whose incidence rate is about 17% of

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emergency department patients with fractures and among those intraarticular fractures of the distal radius fractures account for 25% (*8*). The need to treat distal radius fractures surgically has increased because nonsurgical treatment frequently delays the patient's return to the activities of daily living. With the development of volar locking palmar plates, the volar approach to the distal radius is being increasingly used for fracture management because of its low profile design, neutralizing the load across the fracture site and non requirement of good quality bone (*12*). The complications of volar plate fixation of distal radial fractures including soft-tissue complications, neurovascular complications, osseous complications, complex regional pain syndrome and infection are also increasing significantly (*3*). As for the soft-tissue complications, volar plating is thought to carry a lower risk of tendon irritation and tendon rupture than dorsal plating (*19*). However, there have been some reports of extensor and flexor tendon complications including wrist pain and restriction of motion with volar plating techniques.

Lateral fluoroscopy technique is a common method to determine the length of screw to reduce the injury of extensor tendon and the screw should be in such a way that it is just through the dorsal lateral cortex. In terms of avoiding the flexor tendon injury, in addition to the correct position of the plate, "L" shaped suture should be applied to the PQ muscle as completely as possible to form an effective protective layer between the steel and the flexor tendon. However, some patients with appropriate length of screw in lateral image still appeared to have extensor tendon irritation symptoms (*2*) and PQ repair was so difficult that could not necessarily yield satisfactory results. So it is worth studying how to avoid extensor and flexion tendon injury in operation, preserve the function of flexor tendon and inherent advantages of preserving PQ.

The aims of this study were to retrospective analysis of sixty-five patients with distal radius fracture from February 2010 to February 2013 and probe reasons of soft-tissue complications of volar plate fixation for managing distal radius fractures and it's Prevention Strategies while exploring clinical effect of preserving PQ muscle.

PATIENTS AND METHODS

From February 2011 to February 2013, sixty-five patients, aged 20 to 68 years, mean 42.5 years (42 males and 23 females) with distal radius fracture underwent open reduction and internal fixation with the volar locking palmar plates (Depuy company). The causes of injury are fall injuries for 54 cases, car accidents for 11 cases. Those fracture cases are classified according to the AO classification in a range of 23A-2 to 23C-3 type. Time from injury to surgery was 0.5 -12 days (with the average of 1.8 days). All operations were performed by the same team of surgeons. Patients were separated into two groups randomly, one with preserving and another with repairing PQ muscles. The group with preserving PQ muscles included 30 patients, with 19 males and 11 females, aged between 21 to 64 years, and with the mean of 40.8 years. The another group with repairing PQ muscle included 35 patients, with 23 males and 12 females, aged between 20 to 68 years, and with mean of 44.3 years. Preoperative X-ray and CT scan were taken to confirm the type of fracture and surgical indications were met for volar plate fixation. 9 patients had cardiovascular and cerebrovascular diseases and were dealt accordingly before and after the surgery.

Each group has 2 cases with primary osteoporosis of Singh index of two. Two groups in age, time from injury to surgery, fracture type, location, follow-up time, the combined ratio of osteoporosis and other aspects of the difference was not statistically significant (Table I).

A traditional Henry approach was used for this surgery. After the initial incision and gradual dissection, Flexor carpi radialis (FCR) tendon was mobilized and retracted to ulnar and using blunt dissection the contents of Carpal tunnel including Hallucis longus were retracted to the ulnar edge to expose PQ with the great attention to protecting the median nerve. During operative exploration of PQ:18 of total 65 cases have transverse rift at distal PQ muscle, while in other 47 cases the PQ muscle was intact. Incision of the PQ muscle in PQ repairing group : PQ muscle was incised in "L"-shaped along the distal and radial line (Fig. 1), taking care to preserve about 0.5 cm of muscle both distally and radially for repair later on. The fractured bone was temporarily fixed with Kirschner wire and after obtaining satisfactory reduction confirmed with C arm fluoroscopy, the DVR plate were used as internal fixation implants. The Plate should be placed carefully not exceeding the distal radius "watershed" region. An ordinary screw was first drilled into the proximal sliding hole, then two locking screws were drilled at the middle column (key stone) and the

Table I . — Characteristics of two groups patients

group	Number of patients	Male/ female	Age years (x ± s)	Mean period from injury to surgery (day, x ± s)	OTA classification A /B/C	Injured side (right/left)	percentage of osteoporosis (%)
Incise of the PQ group	35	23/12	44.3 ± 12.4	1.5 ± 4.1	13/11/1	12 23	5.71 (2/35)
Preservation of the PQ group	30	19/11	40.8 ± 10.2	2.1 ± 3.7	12/8/10	16 14	6.67 (2/30)
Statistics	–	–	0.351	0.182	–	Z = -0.207	–
P	–	0.551	0.728	0.857	0.724	0.865	0.658

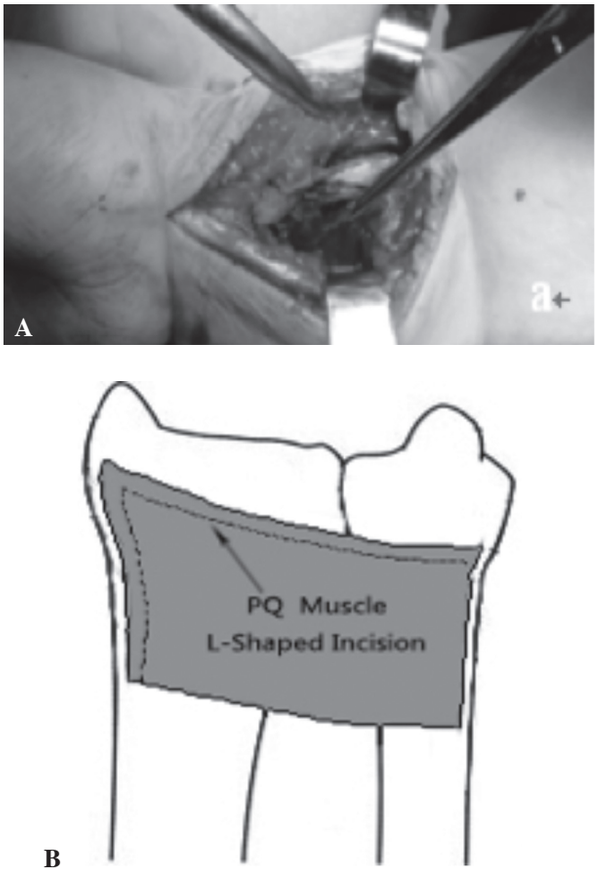

Fig. 1. — **A** PQ was sharply L-shaped incised along its distal and radial borders. **B** Diagram of PQ muscle with L-shaped incision.

remaining screws were drilled after making sure of achieving good reduction with fluoroscopy. While placing the screws, we took great care of not letting drill pierce dorsal cortical bone rapidly and the screw length were reduced 2 mm than the actual length required to ensure that the screw tip did not pass beyond the dorsal cortex. In addition to conventional fluoroscopic method, dorsal tangential perspective fluoroscopy was used to confirm exact screw position (Fig. 2). PQ was finally sutured along the radial and distal borders of the L-shaped incision using 2-0 absorbable sutures. For the PQ preserving group, after exploring PQ muscle, a transverse incisions about 1.5-2.0 cm at distal radius, was made for insertion of the plate. Those cases already present with transverse tear prior to the surgery can be extended appropriately to insert plate. The fractured portion was felt by inserting a thumb through the incision window while providing traction to the injured wrist by the surgeons other hand. After obtaining satisfactory reduction confirmed with C arm fluoroscopy, the fractured bone was temporarily fixed with Kirschner wire and the DVR plate were used as internal fixation implants. Then the locking palmar plate was passed under the PQ muscle, its correct placement being checked by fluoroscopy. sliding and Locking screws were inserted through mini-incisions in PQ (Fig. 3) and distal border of PQ was stitched finally. During the operation, the same technique were taken same as above group.

Postoperative plaster splint were not needed in any patient. Passive functional exercise was recommended after 24h for metacarpo-phalangeal and inter-phalangeal joints after operation. For cases with preserved PQ, Wrist flexion and rotation exercise were recommended after postoperative 3 days and for the cases with repaired PQ they were recommended after 2 weeks after operation. X-ray images were evaluated to start weight-bearing exercises, usually six weeks after operation. The patients were followed up at 1, 2, 6 weeks, 6 and 12 month after operation. Wrist pain, forearm range of motion, grip strength, wrist functional score and evidence of radiographic union were assessed and compared for the both groups.

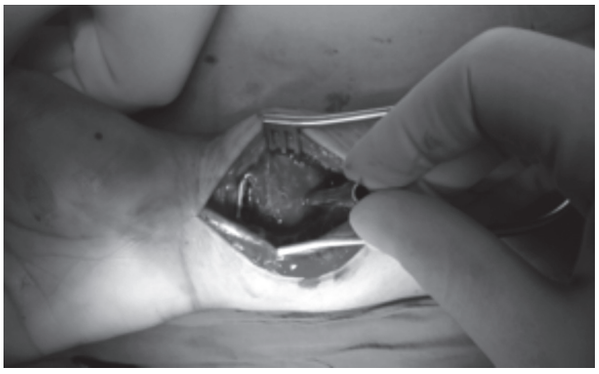

Fig. 3. — Sliding and Locking screws were inserted through mini-incisions in PQ.

All data were reported as mean ± SD and analyzed with SPSS13.0. A t-test was used to test whether there is difference between the two groups or not. Independent sample t-test was used to compare. Age, time from injury to surgery, fracture type and other measurement data. For Gender, the injured area and the ratio of osteoporosis the exact test was used while an unpaired t-test was used to assess differences between PQ preserved and the PQ repaired groups for all outcome measures. Significance was set at $P<0.05$.

RESULTS

All patients were followed up for at least 1-year. Complications of infection, such as tendon and nerve damage did not appear during hospitalization after operation. Fractures healing at 3 months after operation are significant in X -ray and CT imaging. Fixed position and stability were good after operation, but each group had one case with a screw piercing the dorsal cortical. The relevant data regarding the wrist pain, forearm range of motion, grip, strength and imaging data were collected after 2 weeks, 6 weeks, 3months and 12 months respectively. The differences between the two groups were significant regarding the wrist pain, forearm range of motion, grip and strength at 2, 6 weeks after operation, but not significant at 3 and 12 month after operation. The differences between the two groups were also significant regarding wrist functional scores at 6 weeks, but not significant at 3 and 12 month after operation (Table II).

There were no other significant postoperative complications neither clinically nor radiographically but for a few general complications such as haematoma or superficial wound breakdown were present but these were not statistically significant.

DISCUSSSION

Patients with distal radial fractures are becoming increased for surgical treatment recently (*10*). Among these fixations, the volar plates are being increasingly used because of some advantages including reduction in soft tissue complications for it's design and placement compared to the dorsal plate (*6*). But clinical reports about postoperative soft tissue complications of extend and flexion tendon irritation are still not uncommon with the widespread use of volar plate fixation (*5*).

Soft tissue complications such as rupture of Extensor pollicis longus (EPL), extensor tendon irritation and extensor tenosynovitis were commonly reported after volar plate fixation (*1*). Surgeon drills directly through the dorsal cortex and Screw length beyond the dorsal cortex which cause many of the extensor tendons injury are may reasons. The prevention strategies are that surgeon must made drill penetrate dorsal cortical bone gently to avoid sudden piercing and measurement must be really accurate for the screw length. Besides, dorsal carpal tangential radiography were very helpful. This method can greatly reduce postoperative complications of extensor tendon injury (Fig. 4) (*7*). However, in this study, one case each group still showed dorsal cortical screw piercing after operation, that was found in the follow-up CT scan which might have lead to wrist pain in that patient . The reason might be because of covering of the screw tip dorsally by the distal radius fractures fragment that caused dorsal carpal tangential fluoroscopy unable to find that situation. With the dorsal bone fragment displaced or absorbed a few months after operation, dorsal cortical bone screw piercing situation may appear. Therefore, screw length can be further reduced to 75% of the measured length to avoid this situation for these cases. While for these patients with wrist pain, surgery need to be done to remove the overlong screw while avoid unexpected

Table II. — Outcomes at the fellow-up

Outcome	Time point	PQ repaired group (mean)	PQ preserved group (mean)	P
wrist pain (VAS, mean)	1 week	6.31	4.92	0.031
	2 week	5.79	3.59	0.023
	6 week	3.76	2.67	0.041
	3 month	2.33	1.89	0.11
	12 month	1.56	1.43	0.096
forearm range of motion (extension/ flexion, % opposite uninjured side)	1 week	26.1	38.9	0.021
	2 week	30.5	50.3	0.030
	6 week	54.3	65.4	0.042
	3 month	68.9	73.5	0.56
	12 month	87.1	87.8	0.49
forearm range of motion (pronation/ supination, % opposite uninjured side)	1 week	38.6	51.2	0.019
	2 week	50.6	69.4	0.027
	6 week	72.4	85.6	0.036
	3 month	88.9	90.5	0.20
	12 month	92.8	97.9	0.16
grip strength (% opposite uninjured side)	1 week	36.6	47.5	0.041
	2 week	42.1	56.7	0.036
	6 week	66.4	75.4	0.029
	3 month	82.1	85.6	0.14
	12 month	87.9	95.6	0.16
wrist functional (DASH score)	1 week	–	–	–
	2 week	–	–	–
	6 week	26.3	18.4	0.029
	3 month	15.6	13.5	0.13
	12 month	9.5	8.8	0.11

complication in rare cases which screw shanks must be left in situ (*9*).

Due to the structure of the distal radius and the presence of the PQ, the complications caused by flexor tendon are relatively low than that of extensor tendon. At present, for flexor tendon rupture, scholars generally believe that the position of the plate is placed too close to or exceed the "waterline" of the distal radius which makes flexor tendon repeatedly contact with the plate and causes damage to flexor tendon and leads to its rupture (*16,15*). But for most cases with relatively mild flexor tendon irritation symptoms, lack of effective closure and cover of PQ, then lack of protection of flexor tendon above the steel is an another important factor for the flexor tendon irritation symptoms. So in recent years, more attentions have been taken gradually to maintain the integrity of the PQ which can effectively reduce the flexor tendon injury after volar plate fixation of distal radius fracture (*14*). Besides, preservation of the PQ might restore the pronator strength and provide stability to the distal radio-ulnar joint (*18,11*). PQ helps in reducing complications of soft tissues in the volar plate fixation of distal radius fractures, and has received more and more concerns recently.

The PQ muscle is a quadrilateral muscle and is the deepest muscle in the anterior aspect of the forearm. Its relatively wide and flat anatomical cover-

age is in favour of covering volar plate. L-shaped incision of PQ Muscle along its radial and distal borders was always taken for open reduction for distal radial fracture. After hardware implantation, PQ was always repaired by suture to cover the volar plate. But some surgeons including us noticed that it was difficult to repair PQ completely and did not yield satisfactory results (Fig. 5). Even after being sutured, the PQ is often torn when forearm is rotated and patients can not recover its function early. Hershman even reported that there is no advantage in repairing the PQ during volar plating of distal radius fracture after initial incision of PQ compared to the cases without repairing the PQ (*17*). Recently, preserving the PQ during the volar approach for plating of the distal radius has been advocated by some authors including us in order to preserve the function and inherent advantages of PQ (*4*). Heddari *et al* also pointed towards the possibility of sparing the PQ muscle in volar plating of the distal radius (*13*).

In this study, we investigated whether preserving PQ muscle can reduce wrist pain and other soft-tissue complications and early restore of forearm activity, grip strength and wrist function by comparing the two groups. The results indicate that at 6 weeks after operation the preserved PQ group has obvious advantages of reduced wrist pain and early restoration of forearm activity, grip strength and wrist function. Due to the lack of similar literatures to compare our results with, we supposed that this result is because of the preservation of PQ muscle, without significant damage, that allowed it to recover its function immediately after operation. There is no significant difference in these above-mentioned indicators between the two groups at 3 months and 12 months after operation. The reasons may be that forearm rotation, grip strength and other functions are brought about by the combined action of a variety of structures, which are fully recovered in the late postoperative period and in addition to that pronator teres has a compensatory effect which help in early recovery of those functions. Although the success rate of PQ repair is unknown, in our clinical experience of removing the fixation plate,we found in some patients the repair to be truly effective (Fig. 6) and this also might be another one of the reasons to be the difference between those 2 groups to be not significant statistically.

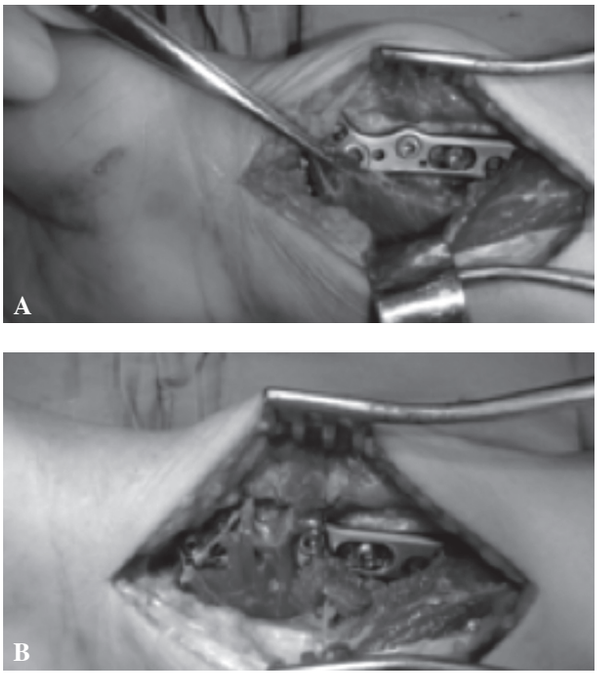

Fig. 5. — **A.** Prepare to repair the PQ muscle. **B.** PQ was repaired after internal fixation of the distal radius and the caliber of the muscle belly available for repair and coverage is poor.

In conclusion, soft-tissue complications of volar plate fixation for managing distal radius fractures is not so rare but this can still be greatly reduced if surgeon take great care in drilling the bone gently and not allowing the screw tip to pierce the dorsal cortex, addition of dorsal carpal tangential fluoroscopy for more accurate screw length and placing the volar plate correctly. Preserving the PQ muscle in this technique has advantages of preventing the flexor tendons from injury, yielding better early wrist functions and shortening postoperative rehabilitation time. There still may be some difficulties for preserving PQ muscles in freeing the fracture fragments sub-periosteally with C-type fractures which require more surgical experience and the correct choice of cases to manage it properly.

Potential weaknesses of this study includes the lack of long follow-up of patients, non-similarity in the extent of damage sustained by bones in each group and also all the fractures did not fell into the

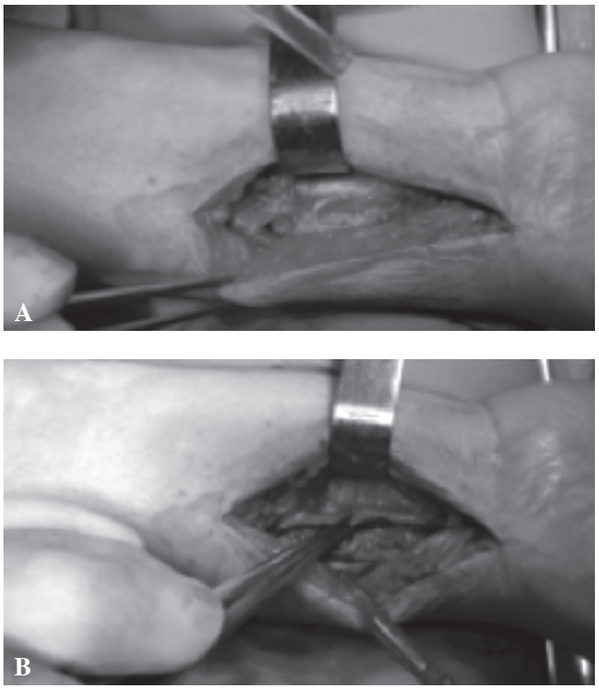

Fig. 6. — **A.** PQ muscle was Well-preserved 1.5 years after surgery. **B.** Remove the internal fixation and PQ can be effective repaired again.

same category of class in their classification. Besides, the wrist pain, forearm range of motion, and wrist functional recovery are also related with fractures reduction and other factors. So prospective clinical studies with more standard surgery technique and longer follow-up with larger sample sizes would be required to provide more definitive conclusions. Despite all these weaknesses, this report is in support of the some easily ignored surgery techniques and PQ preservation technique in volar plate fixation for managing distal radius fractures which can further lessen the soft-tissue complications.

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