The effect of splint use duration on pronator quadratus muscle repair in the fixation of distal radius fractures using volar plates

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Abstract
Distal radius fractures are among the most common orthopedic traumas [1, 2]. Stable fractures can be successfully treated with closed reduction and casting. Fragmented and unstable fractures result in serious complications if they are not correctly treated [2], and a vast majority of intra-articular fractures are treated surgically [3]. Although several surgical methods can be used, volar plate and screw fixation have an essential place among the available methods. Application of a volar plate for internal reduction of a distal radius fracture requires dissection of the pronator quadratus (PQ) muscle from the radial distal end or margins or both. In the USA, 83% of hand surgeons repair the PQ muscle during this procedure [4]. Covering the plate with PQ muscle creates an interposition barrier between the plate and the flexor tendons, which significantly reduces tendon irritation and the risk of tendon rupture [5]. Suturing of the PQ muscle has been reported to increase fracture stability because of the anatomical relationships [6].

The purpose of this study was to verify whether the repaired area of the PQ muscle was torn in patients suffering from distal radius fractures treated surgically with distal anatomic volar plates by postoperative clinical and radiological examination. We hypothesized that the use of splint for 10 days is enough to reduce the tear of the repaired PQ muscle and positively affect the clinical results.

Material and Methods
Patients
Thirty patients with at least 6-month follow-up among 36 patients who were surgically treated for isolated distal radius fracture between June 2015 and December 2016 at the Second Orthopedics and Traumatology Clinic were included in the study, and their results were evaluated. The study design is a prospective cohort. Hospital ethical committee of clinical research approval was obtained for the study. Ethical protocol number of the research is 2016-185. Patients between 18 and 72 years of age who suffered from closed distal radius fractures and provided written consent were considered eligible for this study. Patients younger than 18 years of age, patients with inflammatory arthritis, neuromuscular disorders, history of wrist surgery, open fractures, history of brain damage, as well as pregnant patients, were excluded. Anteroposterior (AP) and lateral wrist X-ray imaging was performed in all patients following evaluation and physical examination in the emergency service. Patients also underwent computed tomography to evaluate the joint surface better.

Keywords: Distal radial fracture, watershed line, pronator quadratus muscle, hemoclips, long-arm splint, volar plate
Surgical Treatment

According to the AO/ASIF classification, unstable type b and type c fractures were surgically treated by the trans-flexor carpal radial approach. The radial margin of the PQ muscle, together with fibrous tissue, was subperiosteally dissected 1 mm proximal to the watershed line (Figure 1). Following the reduction of the distal radius fracture, an anatomical volar plate was used for fixation. The PQ muscle was then reattached to the distal radius using 1.0 absorbable sutures, and three radiopaque hemoclips were positioned on the radial margin (Figure 2). A minivac drain was placed to prevent hematomas, and a long-arm splint was applied.

Figure 3. Water shed line

Figure 3. Radiopaque hemoclips were positioned on the radial margin

Postoperative management

Active finger movement was started only to the extent tolerated by the patient. Perioperative AP and lateral X-ray imaging of the hand and wrist were performed, and patients with no early complications were discharged. The mean duration of the hospital stay was 3 days. Patients were called at 10 and 20 days and at 1, 2, and 3 months for postoperative follow-up, which included physical and radiological examinations (Figure 3).

Figure 3. Radiopaque hemoclips were positioned on the radial margin

The patients were divided into two groups by long-arm splint duration. In Group 1 (n = 16), the splints were removed on day 10. In Group 2 (n = 14), the splints were removed on day 20. Physiotherapist-supervised rehabilitation was started on splint removal. The AP X-rays of patients at follow-up visits were digitally evaluated using Sectra LiteView and were compared in millimeters. Differences in the distance of up to 10 mm, indicating muscle contraction, were considered normal, and differences >10 mm were considered clinically significant [4].

Results

The mean time from injury to surgery was 11.2 h. All surgical procedures were performed under general anesthesia and under an air pressure of 200 mm Hg. A total of 30 patients, 19 (63%) men, and 11 (37%) women, with complete follow-up records, were evaluated and divided into two groups based on splint use duration. One patient was lost to follow-up because of a change in residence (Table 1). The maximum change in hemoclip location was 6 mm. No loosening of hemoclips was observed in any patient.

Table 1. Change in hemoclip distance

<table>
<thead>
<tr>
<th>Group</th>
<th>Day 10</th>
<th>Day 20</th>
<th>Day 30</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>1.3 ± 1.4</td>
<td>1.5 ± 1.5</td>
<td>2.8 ± 1.9</td>
<td>3.5 ± 2.0</td>
<td>4.0 ± 2.0</td>
</tr>
<tr>
<td>Group 2</td>
<td>1.1 ± 1.2</td>
<td>1.3 ± 1.2</td>
<td>2.1 ± 1.8</td>
<td>3.3 ± 1.8</td>
<td>3.8 ± 1.8</td>
</tr>
</tbody>
</table>

Data are mean distance (mm) ± standard deviation

Pronation-supination and flexion-extension range of motion at 6 weeks and 3 months are shown in Table 2. No significant between-group differences in joint range of motion were observed. Although
at the early follow-up, the range of motion in Group 1 patients was
greater than that in Group 2, the difference was not apparent in the
6th week and 3rd month. The Disabilities of the Arm, Shoulder, and
Hand (DASH) Scores and PQ repair in the two groups were also
not statistically significant (p = 0.03).

Table 2. Change in range of motion

<table>
<thead>
<tr>
<th>Range of motion</th>
<th>Week 6</th>
<th>Month 3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion–Extension</td>
<td>60° ± 12°</td>
<td>69° ± 12°</td>
<td>0.65</td>
</tr>
<tr>
<td>Supination–Pronation</td>
<td>120° ± 32°</td>
<td>130° ± 29°</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Data are mean ± standard deviation

Intra-articular screw penetration was not observed in any of the
patients. All surgical procedures were performed by a single
physician. Postsurgical infections, nonunion, acute carpal tunnel
syndrome, and other complications were not observed.

Discussion

In the open reduction of distal radial fractures with volar plates,
most orthopedic surgeons reattach the PQ muscle because of
functional effects on fracture stabilization and considerations for
improving the blood supply of the fracture line [7]. The repair of
PQ muscle contributes to forearm power and stabilization, which
constitutes 21% of the torque during pronation [8]. Gordon et al.
reported that the deep head of the PQ muscle is a dynamic stabilizer
of the radioulnar joint and that it assists in grasping through
muscle contraction during pronation–supination [9]. During the
surgical revision of 20 patients with distal radius fractures and
PQ muscle repair, Brown and Lifchez found that the tendon of
the flexor pollicis longus muscle was accelerated or eroded by
the volar plate [10]. Berglund et al. suggested that after volar plate
surgery, the repaired PQ muscle acted as a soft tissue barrier that
blocked tendon irritation [11]. In a cadaver study, Tanaka et al.
found increased tendon irritation when plates were placed distal to
the watershed line. They also noted the risk of screw penetration
of the joint [12]. In order to minimize these risks, Aldemir et al.
have noted the importance of placing the plates in the proximal of
the watershed line to prevent tendon irritation. They also measured
the depth of the lunate fossa, which is the deepest part of the wrist
joint, like 2.58 mm, and showed that plates applied according to
this distance prevented intra-articular screw penetration [13,14].
In our study, all surgeries were performed by the same surgeon.
Irritation or rupture of the flexor tendon and intra-articular screw
penetration were not observed.

In a study of 112 patients with or without PQ repair, Hershman
et al. found no significant differences between two groups in
wrist range of motion or visual analog score at a mean of 1-year
follow-up [15]. However, four patients required a second surgery,
extensor tendon rupture occurred in two, and intra-articular screw
penetration was observed in one. Swigart et al. placed radiopaque
hemoclips on the repaired PQ muscles of 24 patients and found no
significant differences in the PQ muscle injury level, wrist flexion–
extension, pronation-supination, or grip strength at 3 months
postoperatively [4].

Conclusion

In our study, no loosening was observed in the hemoclips after PQ
repair. The maximum clip separation was 6 mm, which was not
clinically significant. The range of motion of the hand-wrist joints
in the two groups was similar. The splint use duration had no effect
on the outcomes expected from the repair of the PQ muscle.

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Ethical approval

This article contains studies with human participants, and This article does not
contain any studies or animal participant performed by any of the authors.

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