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Isokinetic evaluation of pronation after volar plating of a distal radius fracture

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ABSTRACT

Introduction: Pronator quadratus (PQ) is an important contributor to forearm pronation, and there is concern that volar plating of a distal radius fracture (DRF) may damage the PQ function. The purpose of this study was to determine whether isokinetic pronation strength would decrease considerably after volar locking plating of a DRF, and whether clinical outcomes would be affected by any pronation strength decrease.

Materials and methods: Thirty-four patients of mean age of 55 years (range, 21–74 years) underwent bilateral isokinetic testing at 6 months and 1 year after open reduction and internal fixation using volar plating. Isokinetic pronation and supination strengths were compared between the operated and normal sides. Clinical outcomes such as grip strengths, range of motions and disabilities of the arm, shoulder and hand (DASH) scores were evaluated and analysed for any associations with isokinetic results.

Results: At 6 months, peak torque and total work values for both pronation and supination were lower in the operated sides than in the normal sides (all $p < 0.001$). However, at 1 year postoperatively, the differences in pronation strength were not statistically significant ($p = 0.188$ for peak torque and $p = 0.190$ for total work), whilst supination torque and total work were still significantly lower in the operated sides ($p = 0.015$ and $p = 0.029$, respectively). Decreases in pronation strength were found to correlate significantly with decreases in supination strength and grip power. Wrist motion and DASH scores were not found to be correlated with decrease in pronation or supination strengths.

Conclusions: In patients with a DRF treated by volar plating, pronation strength was not significantly different between the operated and normal sides at 1 year postoperatively, and decreases in pronation or supination strengths were not found to affect clinical outcomes as assessed by DASH scores. This study suggests that dissection of the PQ may have minimal clinical impact on forearm pronation function.

Introduction

Volar open reduction and internal fixation (ORIF) using the volar locking plating system has become a popular option for the treatment of unstable distal radius fractures (DRFs).[1–4] Volar exposure provides wide access to the distal part of the radius and facilitates fracture fragment reduction,[1] and volar locking plate system provides stable fixation to allow early motion.[1,4]

During the volar approach, the pronator quadratus (PQ) is elevated off the radius to accommodate the volar plate.[1,5–7] Repair of the PQ at the end of a procedure is generally considered difficult because the muscle insertion is not strong enough to hold sutures. However, PQ is an important contributor to forearm pronation,[8,9] and a recent study demonstrated that the controlled reduction of PQ function is associated with a significant decrease in pronation torque.[10] To prevent a potential loss of pronation strength, several authors have introduced techniques for repairing the PQ or preserving it during the volar approach using the volar locking plate system.[5,11]

Isokinetic testing provides means of assessing muscle strength. It involves controlling a predetermined speed of motion and improves the *in vivo* assessment of muscle function,[12] and has been used to measure muscle functions postoperatively in various joints.[12–15] The majority of isokinetic studies on the forearm and wrist have been performed in healthy men or athletic players,[10,16–19] other studies have been undertaken on the effects of tendon harvest for thumb carpometacarpal arthroplasty.[20]

The purpose of this study was to determine whether isokinetic pronation strength would decrease considerably after volar locking plating of a DRF, and whether clinical outcomes would be affected by any pronation strength decrease.

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Materials and methods

Study population

We obtained Ethics Committee/Human Studies Committee approval for this study. From May 2008 to August 2009, 98 patients with a DRF were treated by volar plating at the authors' hospital – an urban tertiary referral hospital. The inclusion criteria were (1) an age over 20 years, (2) inadequate initial reduction or loss of reduction within 3 weeks of injury and (3) volar ORIF of a closed DRF without carpal bone or ligament injuries. The exclusion criteria were (1) multiple trauma, (2) an open fracture or fractures with neurovascular injury, (3) the development of complex regional pain syndrome and (4) a history of a condition capable of affecting upper extremity muscle functions, such as, a cerebrovascular accident or Parkinson's disease. Of those who underwent surgery, 34 patients were excluded from the study; six had carpal bone or ligament injuries, 11 had concomitant trauma of other sites, seven had conditions affecting muscle functions and 10 did not visit at 3 months follow-up. The other 64 patients met the inclusion criteria and were approached for enrolment in the study at 3 months follow up, and 43 agreed to participate in the study. Of these, 34 completed isokinetic tests at both 6 months and 1 year postoperatively, and these constituted the study cohort. There were 20 female and 14 male patients of overall mean age 54.6 years (range, 21–74 years). The right wrist was injured in 20 patients (all dominant) and the left in 14 (all non-dominant). Average time from operation to isokinetic testing was 6 months (range, 5.2–7.0 months) and 1 year (range, 0.93–1.22 years). Fracture types are presented in Table 1.

Surgery/postoperative care

All operations were performed by one surgeon (H. G.) under regional or general anaesthesia. At the beginning of each operation, a longitudinal incision was made on the volar side of the distal forearm and the radius was approached through the sheath of the flexor carpi radialis tendon. The PQ was then elevated off its radial insertion, and fractures were reduced and fixed using a volar locking plate system (Acumed, Hillsboro, OR) (Figs. 1 and 2). For plate coverage, the PQ was repaired using absorbable sutures, but loosely and not in its original insertion. Ulnar styloid fractures, when present, were not operated on. No case of apparent instability of the distal radioulnar joint was encountered at the completion of radius fixation. Postoperatively, wrists were immobilised using a short-arm volar plaster splint, and patients were encouraged to perform active shoulder, elbow and finger motion exercises. At 1 week postoperatively, all wrists were placed in a removable wrist brace. Physiotherapy and occupational therapy were started 2 weeks postoperatively. Braces were used for around 6 weeks as required.

Table 1
Types of the fractures.

AO classification	Number
Type A	
A1	0
A2	2 (5.9%)
A3	14 (41.2%)
Type B	
B1	1 (2.9%)
B2	0
B3	1 (2.9%)
Type C	
C1	7 (20.6%)
C2	4 (11.8%)
C3	5 (14.7%)
Ulnar styloid fracture	22 (51%)

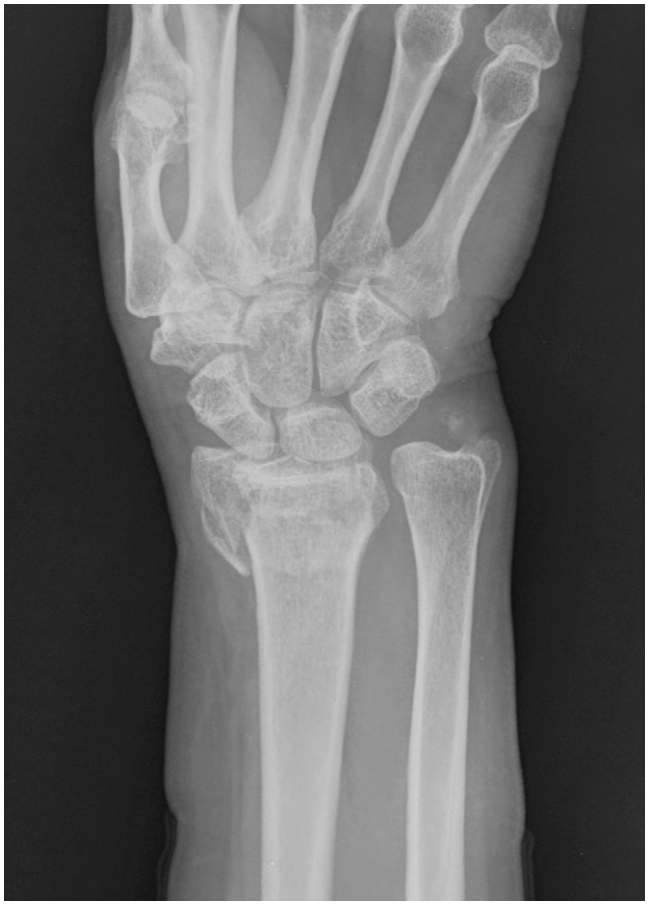

Fig. 1. Anteroposterior radiograph of a patient with a distal radius fracture with marked shortening and comminution.

Outcomes evaluations

Isokinetic testing allows torque to be measured through range of motion (ROM) during constant movement rate and, thus, allows the quantification of functional strength.[12,18,21] Isokinetic testing of forearm rotation has been reported to be a valid, reliable means of evaluating muscle function.[12,13,16,18,22] Testing was done using a Biodex System 3 PRO (Biodex Corp, Shirley, NY, USA) under the guidance of a rehabilitation medicine specialist. Tests were performed during pronation/supination movements of both arms at the same speed load ($90^\circ\ s^{-1}$). Non-involved sides were always tested first. Patients performed 10 isokinetic effort trials for each condition. Peak torque (Nm) was defined as the highest torque measured and total work (J) was defined as the greatest amount of work performed during 10 repetitive isokinetic tests.

Although dominant hand grip power has been shown to be 10% stronger than that of the non-dominant hand,[23] several studies have shown that the pronation and supination powers of dominant and non-dominant forearms are similar by isokinetic testing.[15,18,24] Thus, in this study, kinetic data of affected sides were compared with healthy non-involved sides without adjusting for dominance.

Patients underwent outcome assessments at the same time as isokinetic testing at 6 months and 1 year postoperatively. Functional outcomes included grip power, wrist ROM and results of the disabilities of the arm, shoulder and hand (DASH) questionnaire. Grip power was measured using the Jamar dynamometer (Asimow Engineering, Los Angeles, CA, USA) with the elbow exed at 90° and the forearm in neutral rotation. Results were recorded in kilograms.[25,26] Wrist ROM was evaluated by a