Isometric Testing of Pronation Torque after Paralysis of Pronator Quadratus with Lidocaine
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INTRODUCTION

Open reduction internal fixation with a volar plate is a popular surgical option for the treatment of distal radius fractures. The pronator quadratus (PQ) must be stripped from the distal radius in order to apply the hardware during a volar approach to the distal radius. PQ is an important pronator of the forearm and stabilizer of the distal radioulnar joint. Damage to the PQ during surgical procedures could affect these important functions.

Two muscles are known to be primarily responsible for pronation of the forearm: pronator teres and PQ. To date there has been limited research devoted to defining the relative contribution of the pronator teres and PQ muscles to pronation force of the forearm.

The purpose of this study was to test isometric pronation torque through a range of forearm positions before and after temporary defunctioning of the PQ muscle with EMG guided lidocaine injection in healthy volunteers. Our hypothesis was that peak torque at all positions of rotation would decrease by a statistically significant percentage after injection with lidocaine.

METHODS

The study was approved by the institution’s research ethics board and written informed consent was obtained from all subjects. A custom-made apparatus was built to allow isometric testing of pronation torque at 5 positions of rotation: 90° of supination, 45° of supination, neutral, 45° of pronation and 80° of pronation. It consisted of an armrest and a handgrip attached to a 6-axis load cell. The apparatus was validated using a test-retest design with 10 subjects. The test-retest trial demonstrated no evidence of fatigue with repeated testing. Data from the load cell was processed using custom Matlab programs. Peak torque was the maximum pronation torque recorded during the 10 second isometric contraction. Statistics were performed on the experimental data using a repeated measures model with post-hoc comparisons between pre- and post-lidocaine injections using paired t-tests. Significance values were adjusted for multiple comparisons. After paralysis of PQ with lidocaine, pronation torque decreased by 23.2% (p = 0.0010) at 90° of supination, 16.7% (p = 0.0001) at 45° of supination, 22.9% (0.0002) in the neutral position, 20.4% (p = 0.0066) at 45° of pronation and 22.2% (p = 0.0754) at 80° of pronation. All were statistically significant except at 80° of pronation. The peak torque values before and after injection were highest in the supinated positions (8.2 Nm at 45° of supination) and decreased gradually as the subjects were in more pronated positions (1.8 Nm at 80° of pronation). The test-retest trial demonstrated no evidence of fatigue with repeated testing.

The subjects who underwent injection of saline demonstrated no evidence of pronation torque loss.

RESULTS

Three subjects underwent injection of saline instead of lidocaine and lidocaine. Repeat testing was performed order 30 minutes after injection. Pronation torque measurement has not been used in postoperative outcome analysis of surgical procedures about the wrist but may be helpful.

Future clinical directions for this research include evaluation of pronation torque and proprioception in patients with distal radius fractures treated operatively and non-operatively with or without repair of the PQ.

DISCUSSION

The purpose of the study was to examine the effects of defunctioning the pronator quadratus (PQ) on overall pronation torque. The results demonstrate that in these subjects the ability to produce pronation torque decreased by an average of approximately 21% after lidocaine injection. This magnitude of decrease in torque is consistent across the positions of rotation from 90° of supination (-23.2%) to 45° of pronation (-20.4%). To our knowledge this is the first time the relative contribution of PQ to forearm pronation torque has been demonstrated in the literature.

A limitation of this study is the lack of blinding of subjects to their treatment group which could lead to bias. In the preliminary testing of saline injections instead of lidocaine it was noted that the injections of saline were significantly more painful than lidocaine making randomization and blinding very difficult. There was no decrease in torque values in the subjects injected with saline. To try and minimize the effect of fatigue the order the angles were tested was randomized. It was also shown in the validation study that repeated testing 30 minutes apart demonstrated no effect of fatigue.

The PQ is known to be an important pronator of the forearm and stabilizer of the distal radioulnar joint. Open reduction internal fixation of distal radius fractures damages the PQ. This may result in a pronation torque deficit. Functional significance of this loss has yet to be shown. Pronation torque measurement has not been used in postoperative outcome analysis of surgical procedures about the wrist but may be helpful.