Anatomical parameters of pronator quadratus: a cadaveric study

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Abstract

The pronator quadratus muscle separates the underlying bone from the tendinous and neurovascular structures of the distal volar forearm. whilst the width and extent of pronator quadratus has been determined previously studies have not documented cadaveric thickness. the aim of this study was to determine the thickness of the muscle relative to clinically useful radiographic markers.

Thirty forearms were dissected from 15 cadavers. pronator quadratus and the lunate fossa were fully exposed via a volar approach. Depth measurements were taken using a caliper at interval distances from the lunate fossa.

The width of the pronator quadratus muscle measured 18% of radius length in our sample regardless of sex. Males had significantly thicker pronator quadratus muscles than females which was most marked at 2cm from the lunate fossa (3.27mm 2.20mm, p=0.004). Significance was retained when muscle thickness was expressed as a percentage of radius length (1.3%, 0.97%, p = 0.028). Pronator quadratus had a reliable thickness of only 1-2mm over the course of the first 4cm from the lunate fossa.

Keywords: pronator quadratus, muscle, depth, cadaver

Introduction

The pronator quadratus (PQ) muscle arises from the distal fourth of the ulna and inserts onto the distal fourth of the radius. The PQ muscle is composed of a superficial part, primarily involved in pronation movements providing 20% of pronation strength[1] and a deep part which inserts into the joint capsule stabilising the distal radioulnar joint.[2] The bulk of this muscle separates the underlying bone from the flexor tendons, nerves and arteries of the distal volar forearm. Whilst the width and extent of pronator quadratus has been determined previously, studies have not examined its cadaveric thickness.[3, 4] Cadaveric muscle thickness is widely used as a marker of muscle cross sectional area[5, 6] which gives insight into the potential tension,[7] strength[8] and function[9] of skeletal muscle. The aim of this study was to determine the extent and thickness of the pronator quadratus muscle relative to clinically useful radiographic markers. We then discuss the implications with regard to distal radius fractures and distal radius volar plate fixation.

Materials and Methods

30 forearms (15 left, 15 right) were dissected from 15 cadavers (7 female, 8 male) fixed using Vickers Cambridge Mix©. Flexor digitorum superficialis, flexor digitorum profundus, and flexor pollicis longus were all divided to expose the pronator quadratus. A wrist capsulotomy was performed to allow visualisation of the bony lunate fossa. The deep fascia overlying pronator quadratus was removed to allow accurate determination of its proximal and distal borders and thickness. All measurements were taken with the forearm supinated. A vertical Line through the Lunate Fossa (LLF) was marked. (Figure 1) The Midpoints of the Distal Radius (MPDR) at LLF and Midpoint of the Proximal Radius (MPPR) at the border of PQ, were found and a Line joining the Midpoints (LMP) was drawn (dotted line, Figure 1). Measurements were taken with a calliper at centimetre unit distances from the LLF.

Results

Our cadaveric sample consists of a Caucasian population with a mean age of 81 years (range 56 – 95). Data did not reflect a normal distribution at the proximal and distal extremes due to ceiling effects therefore a Levene's test for equality was used to validate the data. A two tailed t-test was subsequently chosen to assess for significance. No significant difference was found between the left and right forearms for any measurements therefore results were pooled.

Males were found to have significantly wider PQ muscle (see table 1) of 46.7mm versus 40.4mm in females (p=0.001). The sex difference in PQ width was due to the location of the proximal border of PQ, with males having a mean distance from the lunate fossa of 54.79mm versus 48.7mm for females (p=0.003). The distal border of PQ was relatively constant at around 8mm from the lunate fossa. When the width measurements were expressed as a proportion of radius length all p values rose above 0.05 suggesting that sex differences in width reflect an underlying size difference. Taking the data together we can conclude the PQ muscle runs over 18% of total radius length in our sample (17.3 – 18.9%, 95% CI) starting 3.4% of radius length from a transverse line drawn through the lunate fossa (3.1 – 3.7% 95% CI).

Depth measurements showed significant variation between males and females. At 1, 2, 4 and 5 cm from the lunate fossa there was a significant difference in absolute PQ thickness between males and females. (see table 2) When these measurements were expressed as percentage of radius length there remained a significant difference between these two groups at 2, 4 and 5cm from the lunate fossa showing that sex remains a significant factor in determining PQ thickness independent of radius length. This difference was most marked at 2cm from the lunate fossa as shown in figure 2.

Discussion

The distal border of PQ lies close to the wrist joint and is a useful intraoperative marker for volar plate placement in the management of distal radius fractures.[4, 10] Our cadaveric study allowed unhindered dissection to bony points of contact, giving in mortis measurements for the distal border of PQ at 8mm from the lunate fossa which is closer than previous in vivo studies suggest at 12mm.[4] This small difference is significant to preoperative templating and intraoperative plate placement for distal radius fixations where millimetre changes alter the Soong grading, a radiographic grading system of distal plate placement relative to the volar rim of the distal radius. [11]

We found a reliable PQ thickness of only 1-2mm in an elderly population. Whilst this has shown to be thicker in vivo in younger individuals under ultrasound[12] these imaging methods show poor reliability for deeper muscles.[13] Our direct visual measurement of PQ thickness validates the sex difference previously observed under ultrasound imaging.[12] PQ was found to be at it thickest at 2-3cm from the lunate fossa in both sexes, this region corresponds to the pronator fossa, a scalloping of the distal volar radius containing the belly of pronator quadratus.

In the setting of distal radius fractures, tendons may be injured acutely or undergo attritional rupture with either conservative or surgical management. Flexor tendon rupture during the conservative management of a wrist fracture has been reported between 4 hours[14] and 30 years[15] after the fracture where the patient usually reports a sudden loss of function. Surgery may injure flexor tendons intraoperatively or via attritional rupture which is usually attributed to implant prominence with Soong grades 1 and 2.[16, 17] This complication contributes to significant morbidity including further surgery in the form of tendon transfer, grafting or direct repair[18] which carries the risk of adhesions and subsequent stiffness.

After volar plate fixation of distal radius fractures some authors advocate PQ repair to protect the deep contents of the wrist and improve postoperative pain.[16, 19, 20] Some studies however remain inconclusive being unable to detect a significant benefit in terms of functional outcome.[16, 21]

We suggest that in an elderly population bony spurs of greater than 2mm in females and 3mm in males represent a potential danger to the deep flexors of the wrist and hand. The greatest risk of PQ puncture is at the extremes of PQ width where the muscle thins. The flexor tendons are relatively fixed by the carpal tunnel distally so we would expect the distal centimetre of the radius to be the highest risk region for tendon irritation from bony spurs. The greatest bulk of pronator quadratus lies at 2-3cm from the lunate fossa affording better protection. Surgeons should take this into account when deciding to treat the elderly distal radius fracture in a conservative manner. The authors advise repair of PQ intraoperatively after distal volar radius plate fixation as a barrier to tendon irritation.

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- All authors contributed to the study design and manuscript writing. Joseph Duncumb collected all data performed analysis. All authors revised previous versions of the manuscript. All authors have read and approved the final manuscript.

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Figures

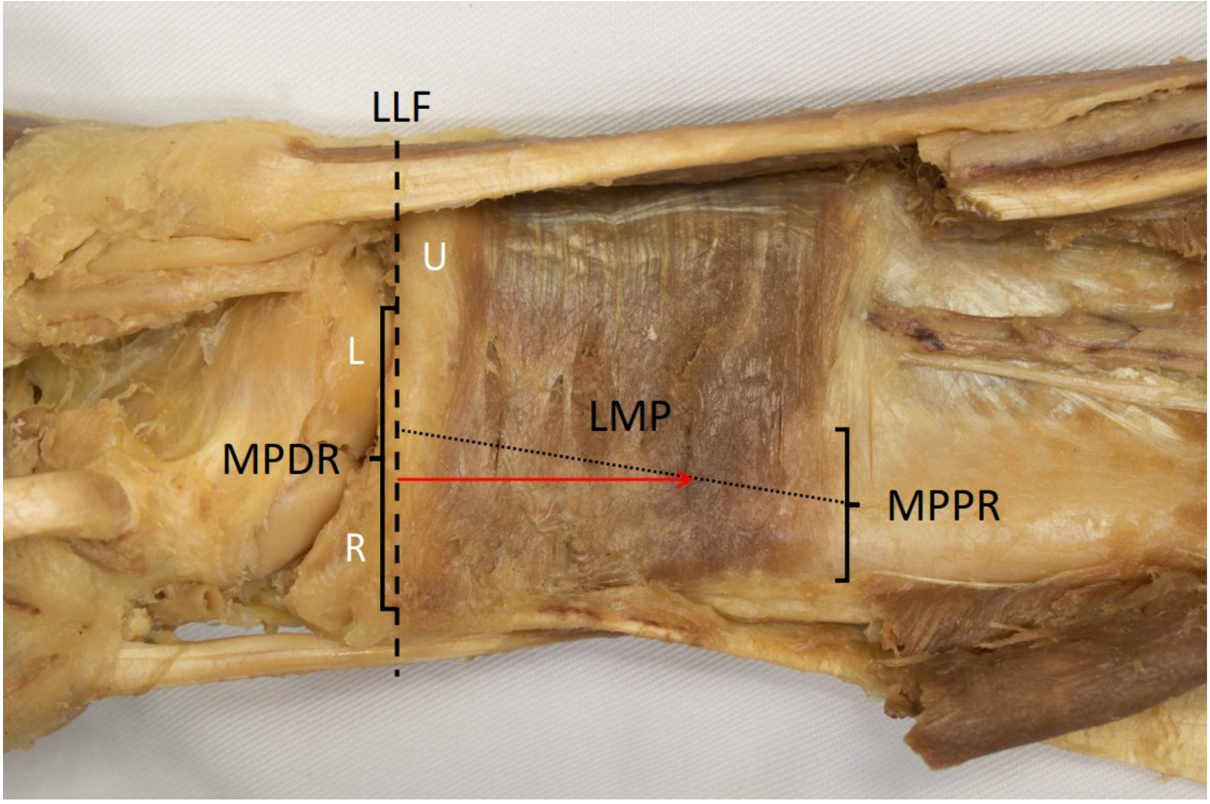

Figure 1. Dissection of Pronator Quadratus.

U, Ulnar; R, Radius; L, Lunate; LLF, Line through Lunate Fossa; MPDR, Midpoint of Distal Radius; LMP, Line through Mipoints; MPPR, Midpoint of Proximal Radius. The red arrow demonstrates a point 3cm from LLF.

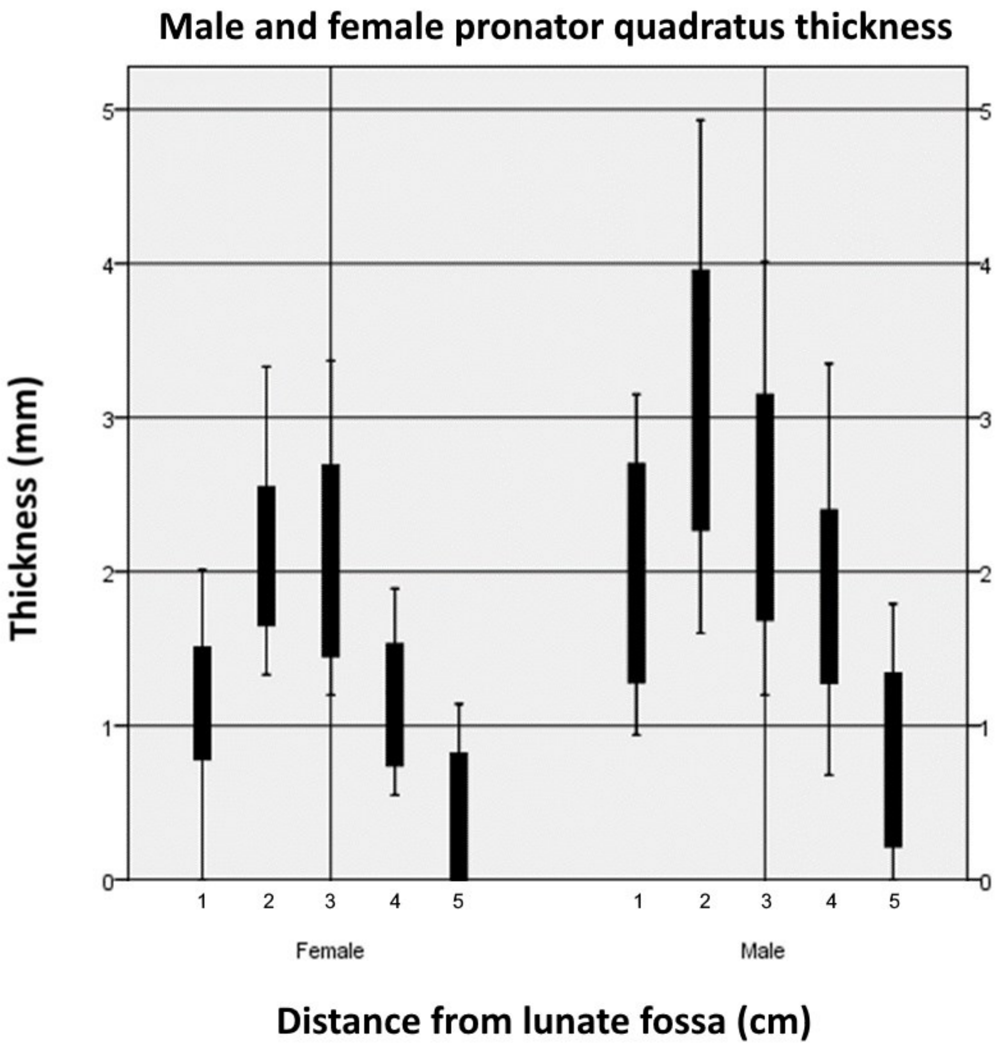

Figure 2. Male and female pronator quadratus thickness showing range (line) and interquartile range (box)

Tables

	Male mean	Female mean	P value
Distal border (mm from LF)	8.07	8.34	0.685
Proximal border (mm from LF)	54.79	48.70	0.003*
Pronator Quadratus width (mm)	46.71	40.36	0.001*
Radius length (mm)	253	227	0.000*
Distal border (% of radius length from LF)	3.19	3.67	0.078
Proximal border (% of radius length from LF)	21.61	21.42	0.818
Pronator Quadratus width (% of radius length)	18.43	17.75	0.400

Table 1. Width measurements of Pronator Quadratus.

LF = Lunate fossa, *denotes significance beyond P = 0.05

		Distance from lunate fossa (cm)				
	Sex	1	2	3	4	5
Mean depth	Male (mm)	2.03	3.27	2.50	1.87	0.85
	Female (mm)	1.31	2.20	2.08	1.19	0.34
Difference		0.71	1.07	0.42	0.68	0.51
P value		0.025*	0.004*	0.168	0.008*	0.020*
Mean depth	Male (%)	0.81	1.30	0.99	0.74	0.34
Mean depth	Female (%)	0.58	0.97	0.92	0.53	0.16
Difference		0.23	0.33	0.07	0.22	0.18
P value		0.078	0.028*	0.599	0.035*	0.043*

Table 2. Depth measurements of Pronator Quadratus.

% = percentage of total radius length, *denotes significance $P < 0.05$