35th SITEMSH congress

Functional Anatomy of Flexor Pronator Muscles

As a Dynamic Stabilizer Against Elbow Valgus Stress

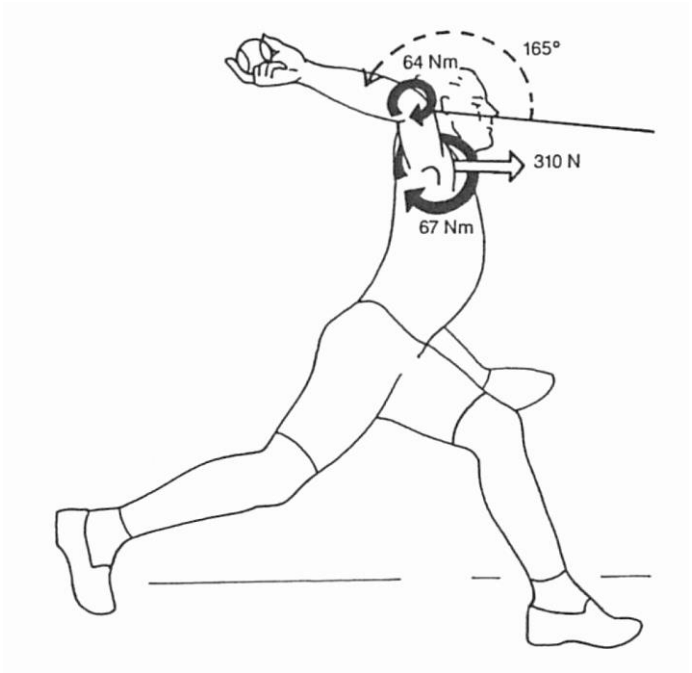
Otoshi K[1], Kikuchi S[2], Sato R[2], Igari T[2], Kaga T[1], Shishido H[2], Konno S[2]

1. *Department of Sports Medicine, Fukushima Medical University School of Medicine*
2. *Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine*

Background$_1$

The load on the MUCL during pitching appears to be near its maximum capacity

Fleisig GS AJSM1995



Varus torque on MUCL during pitching

$64 \times 0.54 = 34.6 Nm$

Failure strength of MUCL

$32.1 Nm$

MUCL: Medial ulnar collateral ligament

Background$_2$

FPMs has been reported to dynamically stabilize the elbow joint against valgus stress.

✓ *Clinical studies*	*Hamilton CD.JSES 1996* *Osbahr DC AJSM 2011*
✓ *Anatomical studies*	*An KN J Biomech 1981* *Davidson PA AJSM 1995*
✓ *Electromyographic studies*	*Sisto DJ AJSM 1987* *DioGiovine MM JSES 1992* *Hamilton CD JSES 1996*
✓ *Biomechanical studies*	*Park MC JBJS 2004* *Lin F JSES 2007* *Udall JH JSES 2009*

FPMs : flexor pronator muscles

Clinical Studies

- ✓ *Decrease in FPMs activation in pitchers with valgus instability during acceleration phase*

  Hamilton CD JSES 1996

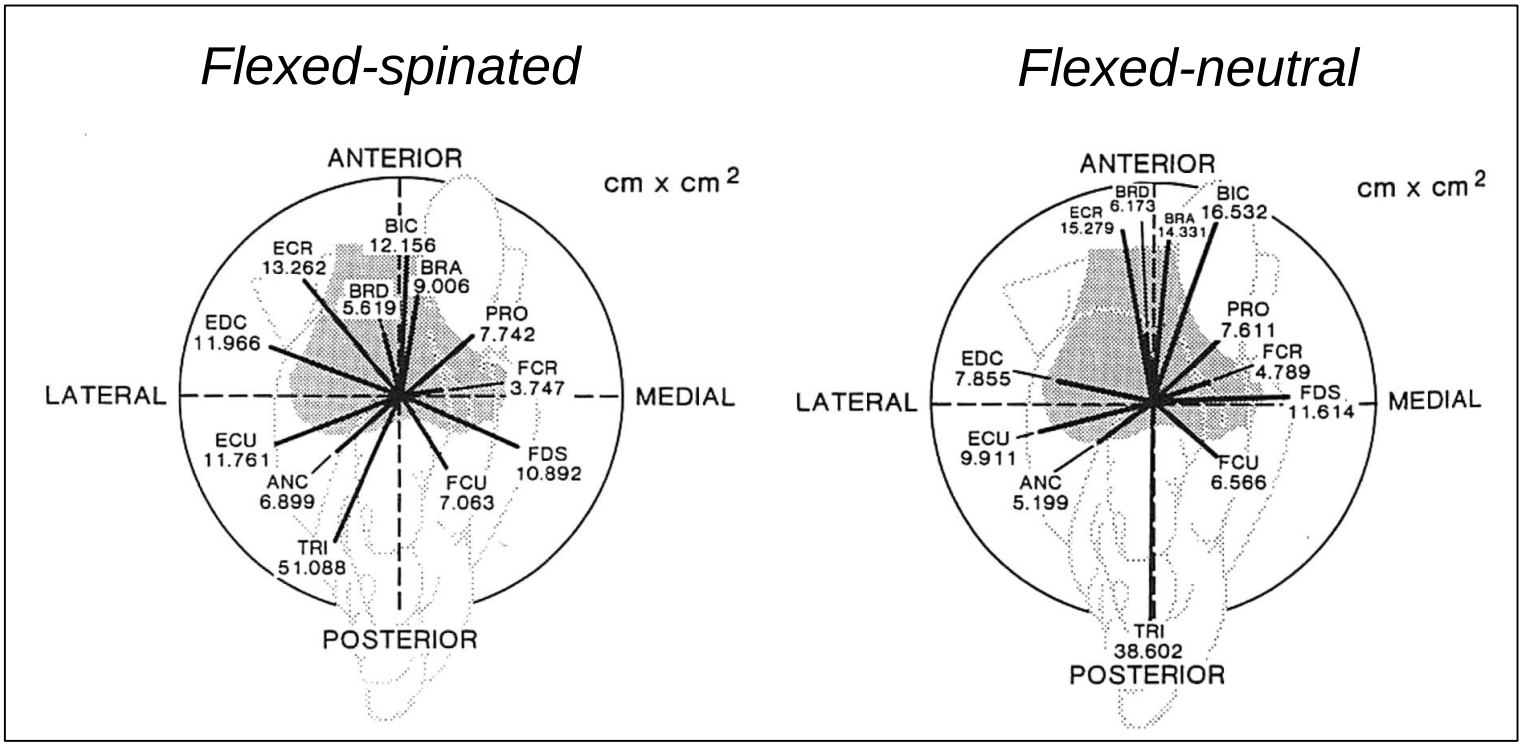
- ✓ *Combined FPMs and MUCL injuries in baseball players may portend a worse prognosis*

  OsbahrDC AJSM 2010

Dysfunction of FPMs related to elbow disorders caused by MUCL insufficiency

Anatomical study[1]

An KN J Biomech 1981

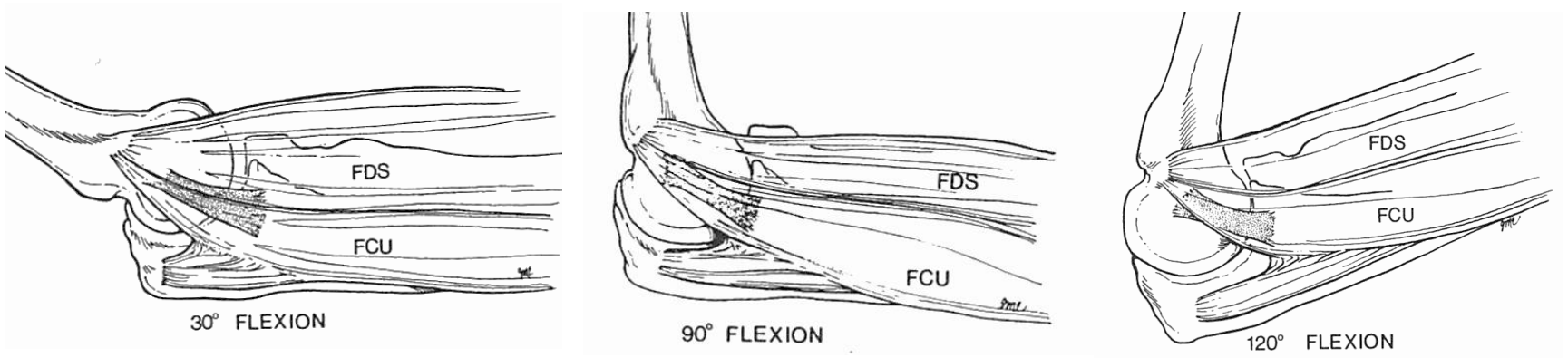


FCR, FDS, PRO (PT), and FCU were the major muscles producing varus forces for the elbow

FCR: flexor carpi ulnaris, FDS: flexor digiturum superficialis, PRO(PT): pronator teres, FCU: flexor carpi ulnaris

Anatomical study[2]

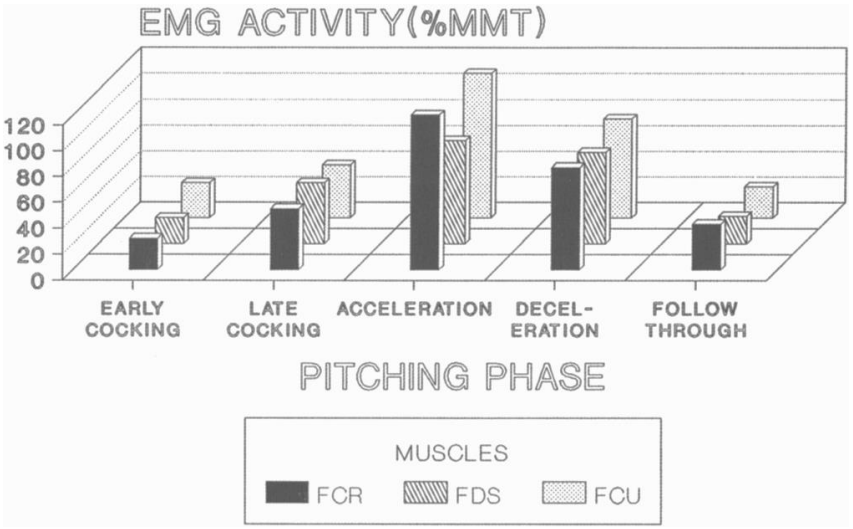
Davidson PA AJSM 1995

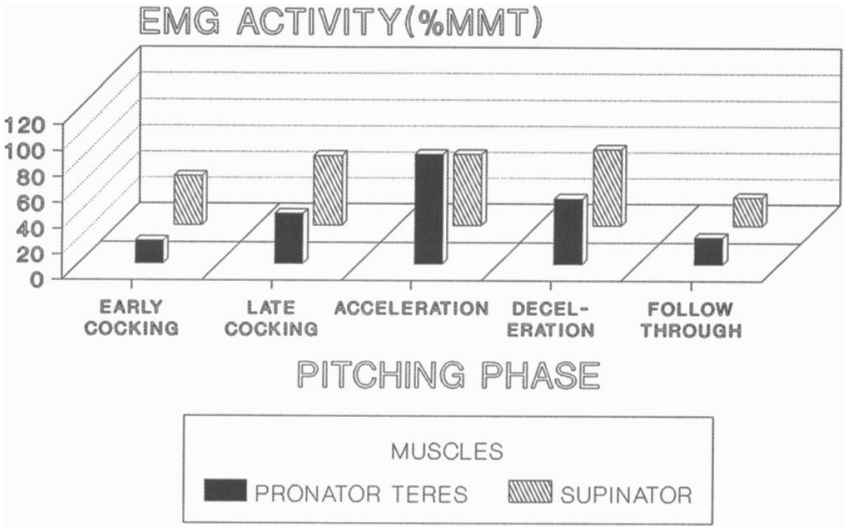


FCU and FDS were the predominant musculotendinous unit because of their position directly over the MUCL in the elbow flexion position

Electromyographic Study

DioGiovine MM JSES 1992





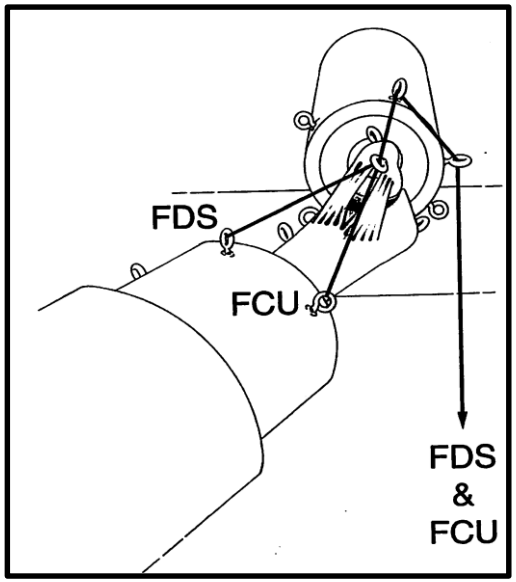
FCR, FDS, FCU, and PT demonstrated very high activity during the acceleration to deceleration phase

PT: pronator teres

Biomechanical Studies

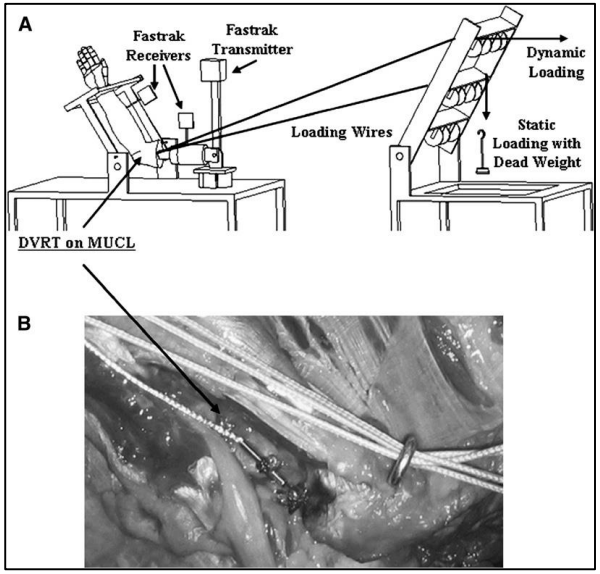
Park MC JBJS 2004, Lin F JSES 2007, Udall JH JSES 2009

Park MC 2004



FCU>FDS

Lin F 2007



FCU>FDS>PT

Udall JH 2009

FDS>FCU=PT

FCU and FDS were the primary stabilizers for achieving elbow valgus stability

Limitations of Previous Studies

Focus limited to:

- ✓ *Muscle volume / Relative position to MUCL*
  in anatomical studies
- ✓ *Electrophysiologic activation*
  in electromyographic studies
- ✓ *Running route of each FPMs*
  in biomechanical studies

Areas in Need of Clarification

Precise anatomy *of FPM proximal origin*

Using anatomical study

In vivo kinematics *of the elbow joint during active contraction of FPM*

Using ultrasonographic study

Anatomical Study

The proximal origins of the flexor–pronator muscles and their role in the dynamic stabilization of the elbow joint: an anatomical study

Kenichi Otoshi · Shin-ichi Kikuchi · Hiroaki Shishido · Shin-ichi Konno

Otoshi K. et al. Surg Radiol Anat 2013

Anatomical Study

Material and Methods

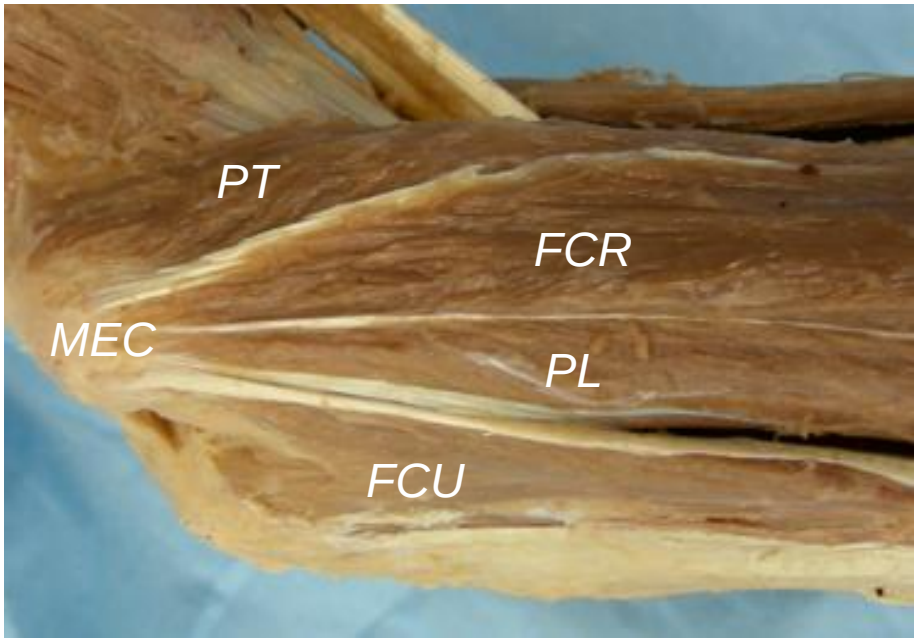
52 elbows *from 26 donated formalin-fixed cadavers*

13 male
13 female
mean 81.5 years
(64-97 years)

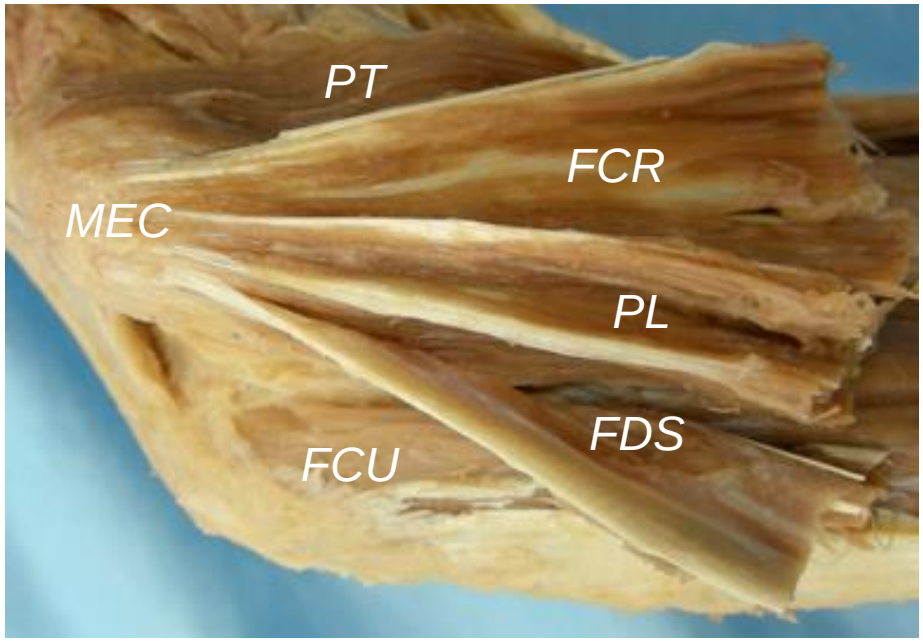
Anatomical Study

Superficial Dissection of the FPMs

Fascia removed



Muscle removed



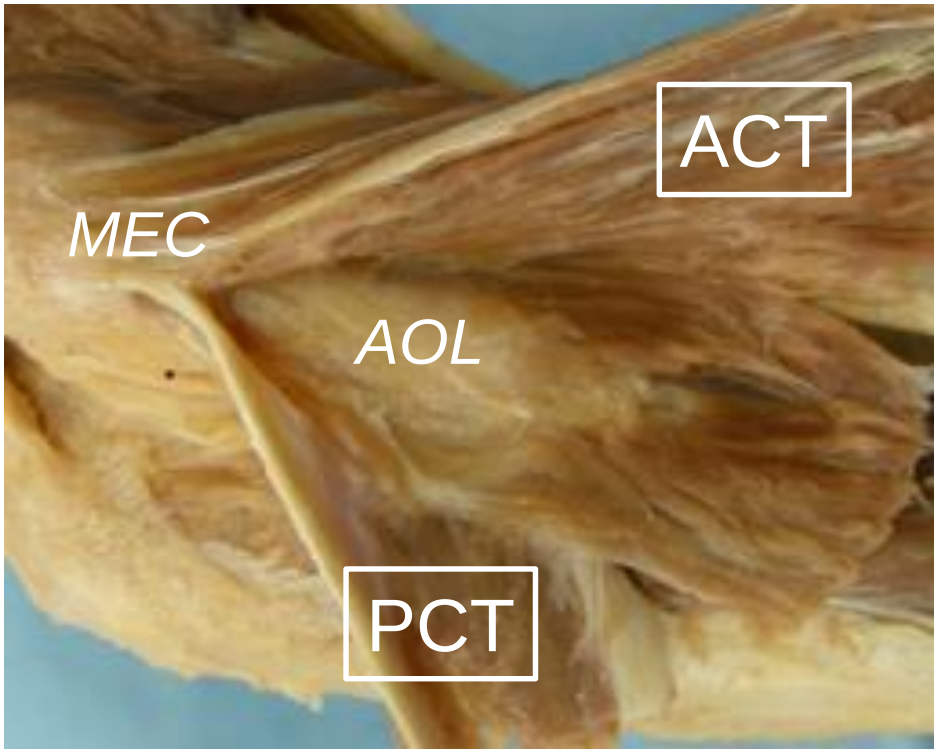
Each FPMs were identified and separated by distinct

Intermuscular fascia

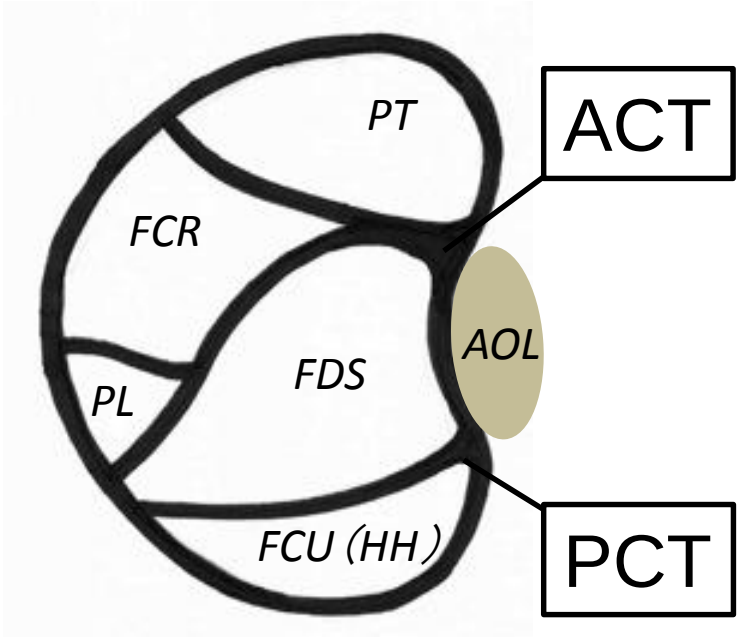
MEC: medial epicondyle

Anatomical Study

Deep Dissection of the FPMs



Schema of AOL and FPMs

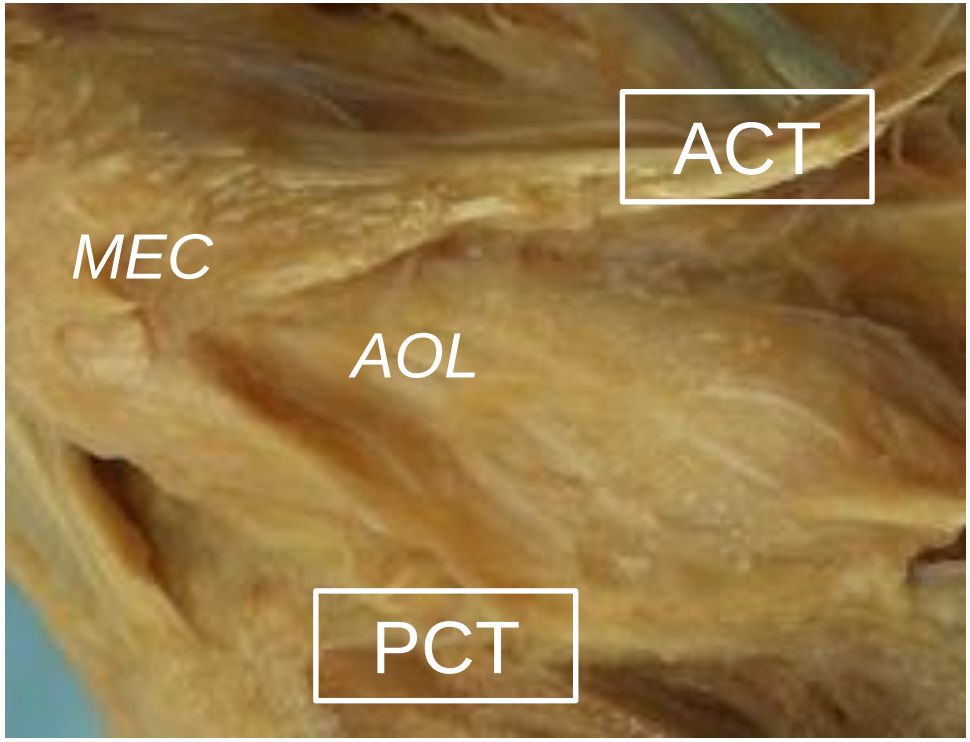


FPMs formed the **common tendons (ACT&PCT)** *at their proximal origin*

AOL: anterior oblique ligament, ACT: anterior common tendon, PCT: posterior common tendon

Anatomical study

Proximal Origin of Common Tendons



ACT passed across the medial joint line in

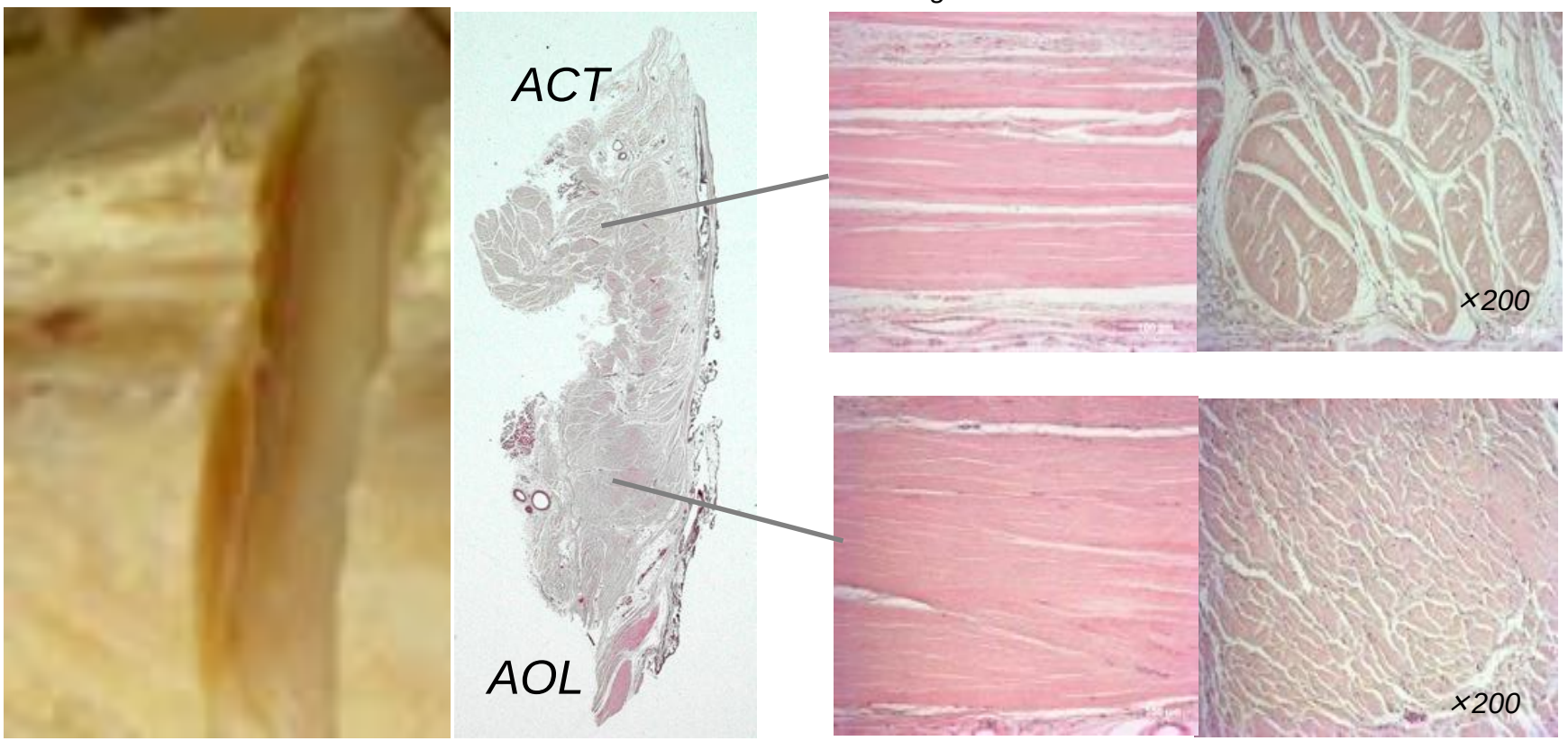
45 of 52 elbows

(86.5 %)

ACT: Attached to the medial epicondyle and the medial joint capsule and run parallel to the AOL

Anatomical Study

Histological Examination of ACT

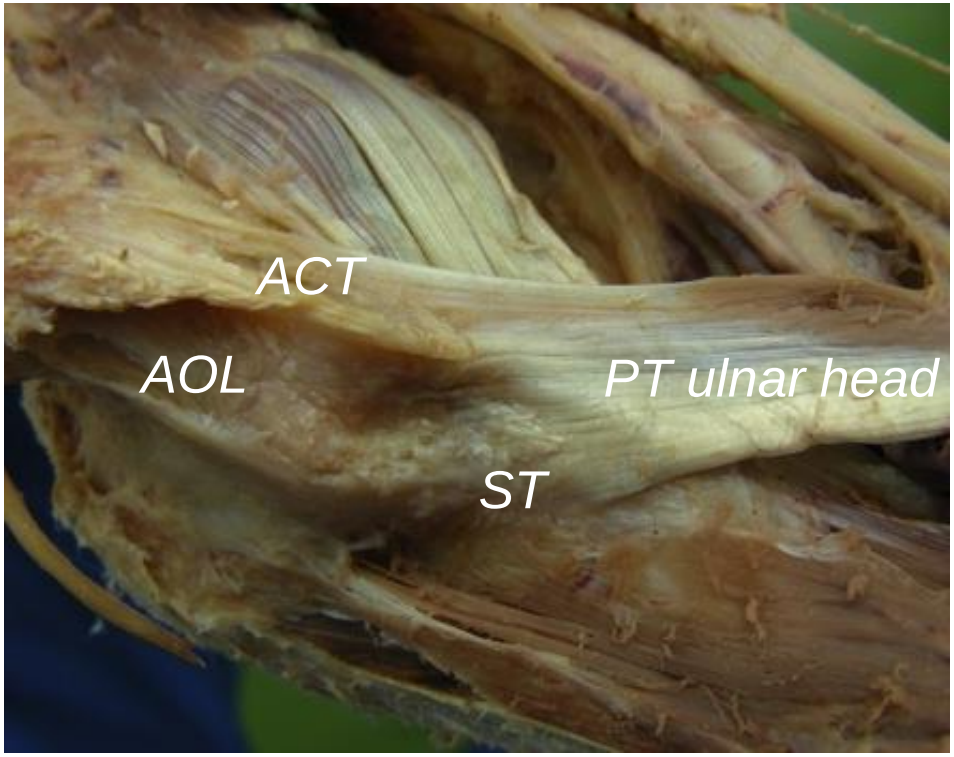


The histological morphologies of ACT and AOL were

very similar

Anatomical Study

PT Ulnar Head Anatomy



The PT ulnar head was observed in

48 of 52 elbows

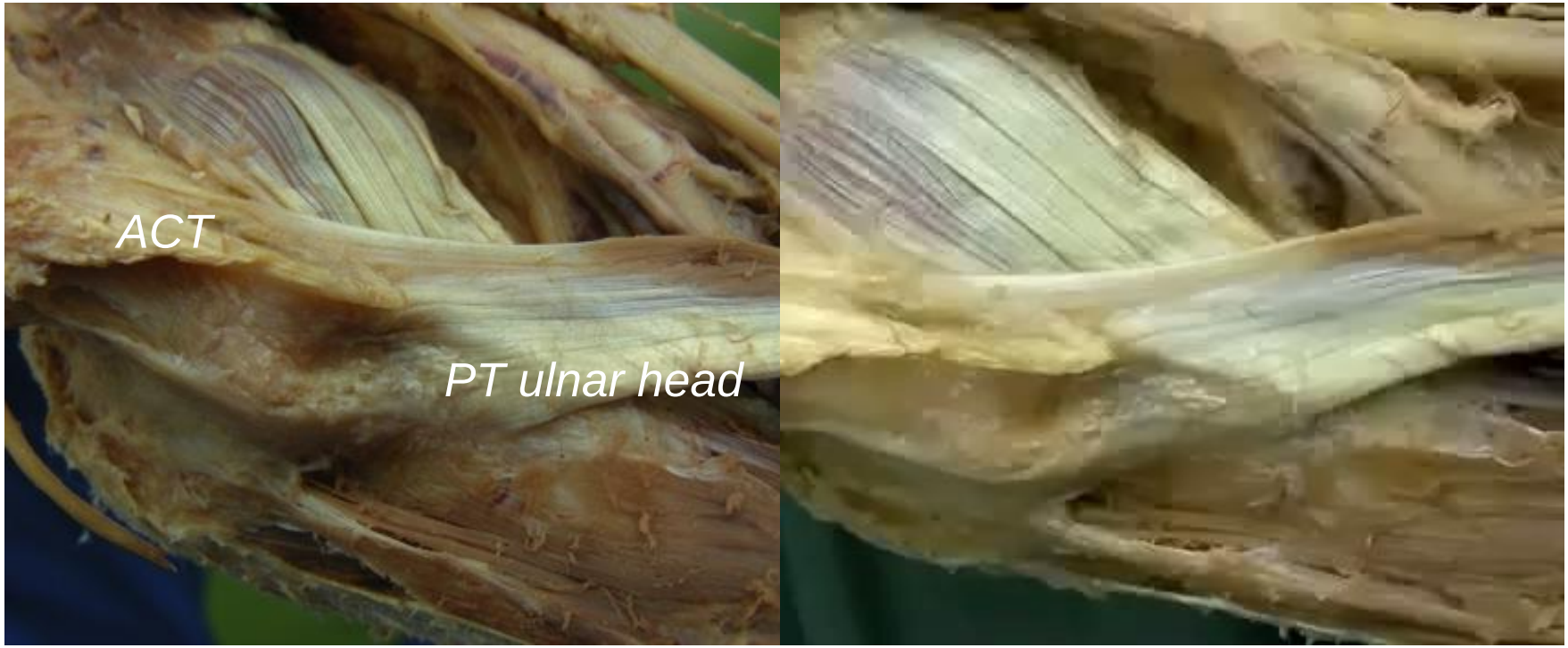
(92.3 %)

The upper part of the PT ulnar head (= humeral branch)

***transitioned directly** into the ACT*

Anatomical Study

Dynamic PT Ulnar Head Analysis



The strain on the ACT increased as the humeral branch of PT ulnar head was tensioned.

Anatomical Study
Summary of Results

- ✓ *FPMs form the common tendons (ACT & PCT) at their proximal origin, and run parallel to the AOL*
- ✓ *The histological morphologies of ACT and AOL were very similar*
- ✓ *Humeral branch of PT ulnar head transitioned directly into the ACT and altered the strain*

Ultrasonographic Study

ULTRASONOGRAPHIC ASSESSMENT OF THE FLEXOR PRONATOR MUSCLES AS A DYNAMIC STABILIZER OF THE ELBOW AGAINST VALGUS FORCE

KENICHI OTOSHI, SHINICHI KIKUCHI, HIROAKI SHISHIDO and SHINICHI KONNO

Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine

Otoshi K. et al. Fukushima J Med Sci 2014

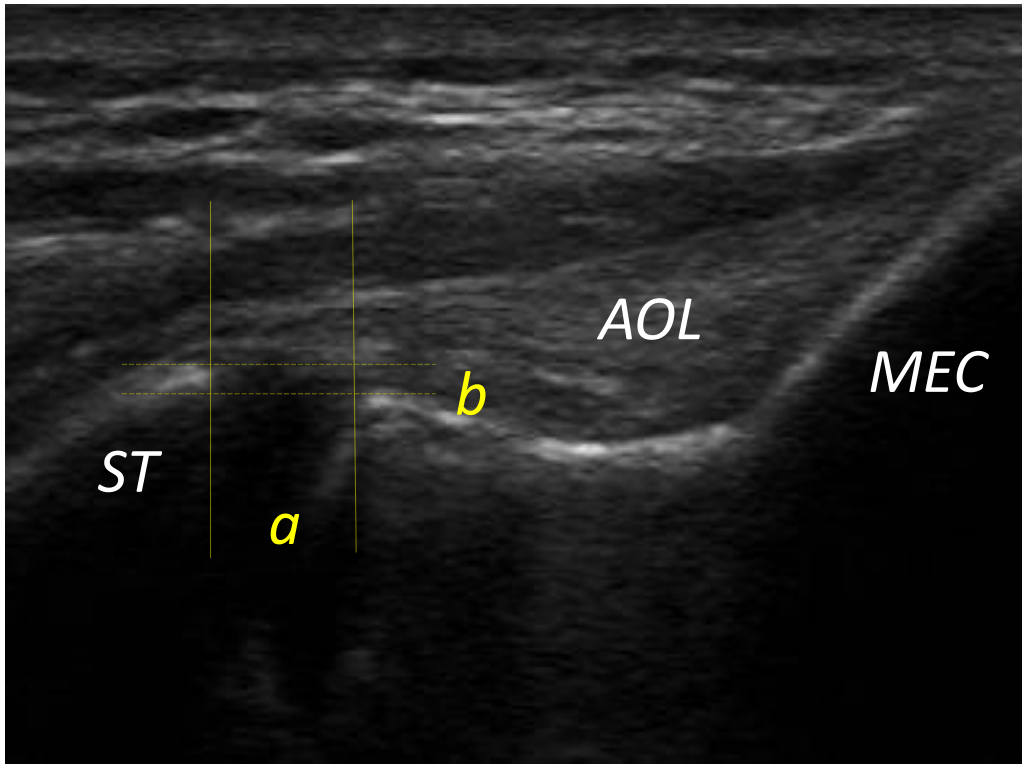
Ultrasonographic Study

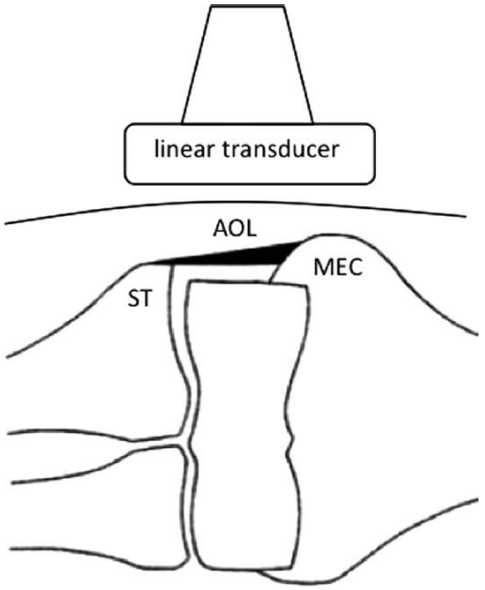
Materials and Methods

24 elbows from 12 healthy male adult volunteers

- ✓ *aged 24-39 years (mean 30.1 years)*
- ✓ *Elbow 90° flex and forearm supinated position*
- ✓ *Manual elbow valgus force was applied by examiner*

Ultrasonographic Study
US Image Assessment





Joint space (a) and medial shift of ST (b) were measured

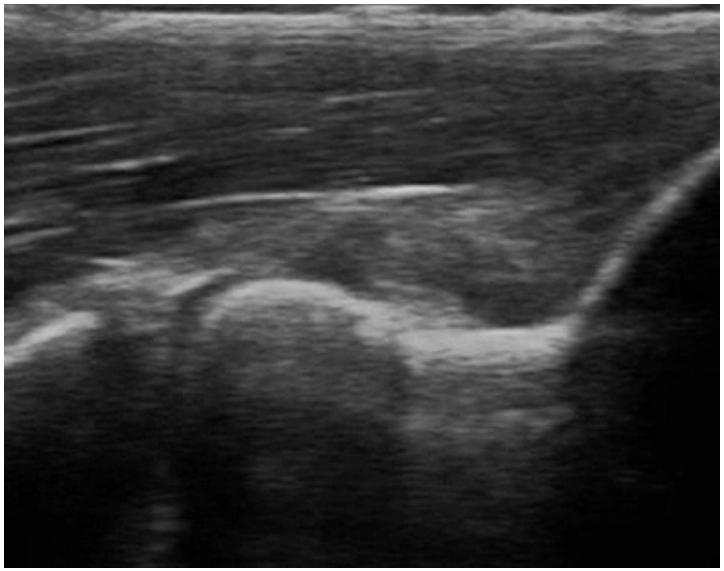
ST: sublime tubercle

Ultrasonographic Study

Dynamic Assessment

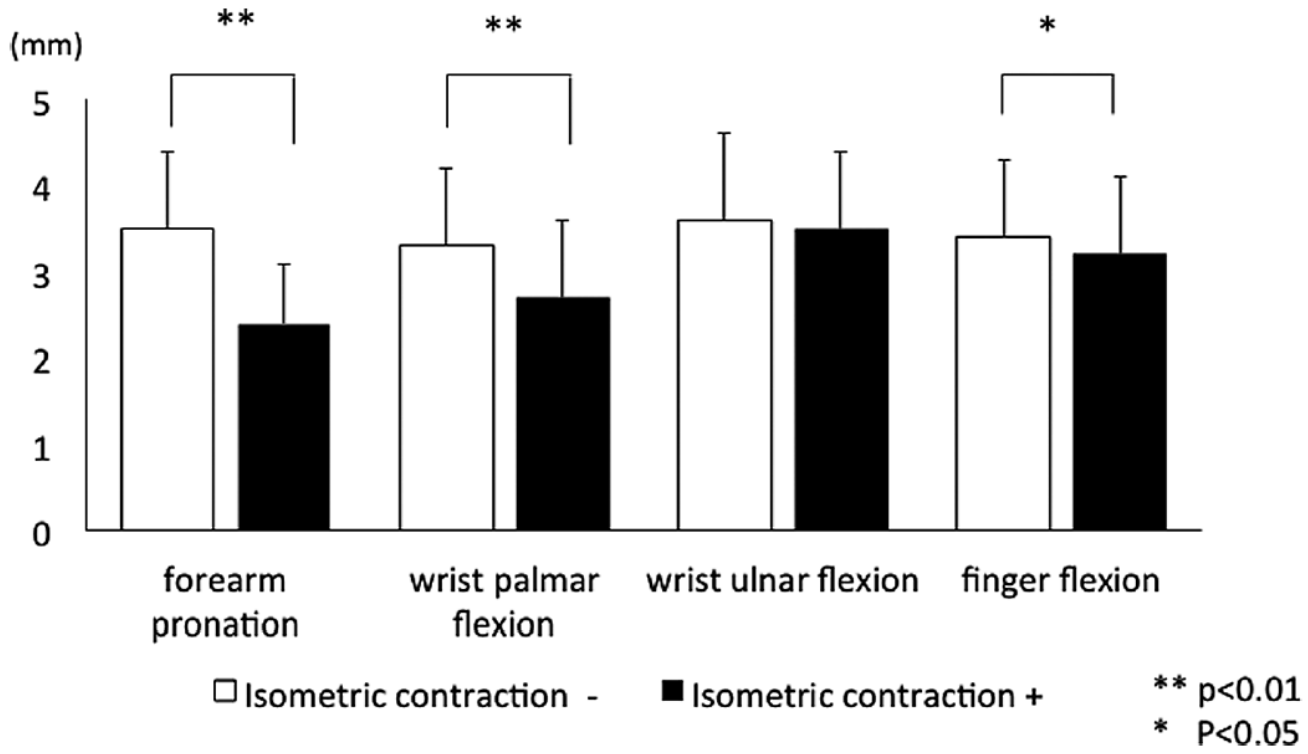
Change of joint space and medial shift of ST were observed during isometric contraction of each FPMs

Isometric contraction	*Main activated muscles*
Forearm pronation	*PT*
Wrist palmar flexion	*FCR*
Wrist ulnar flexion	*FCU*
Finger flexion	*FDS*



Ultrasonographic Study

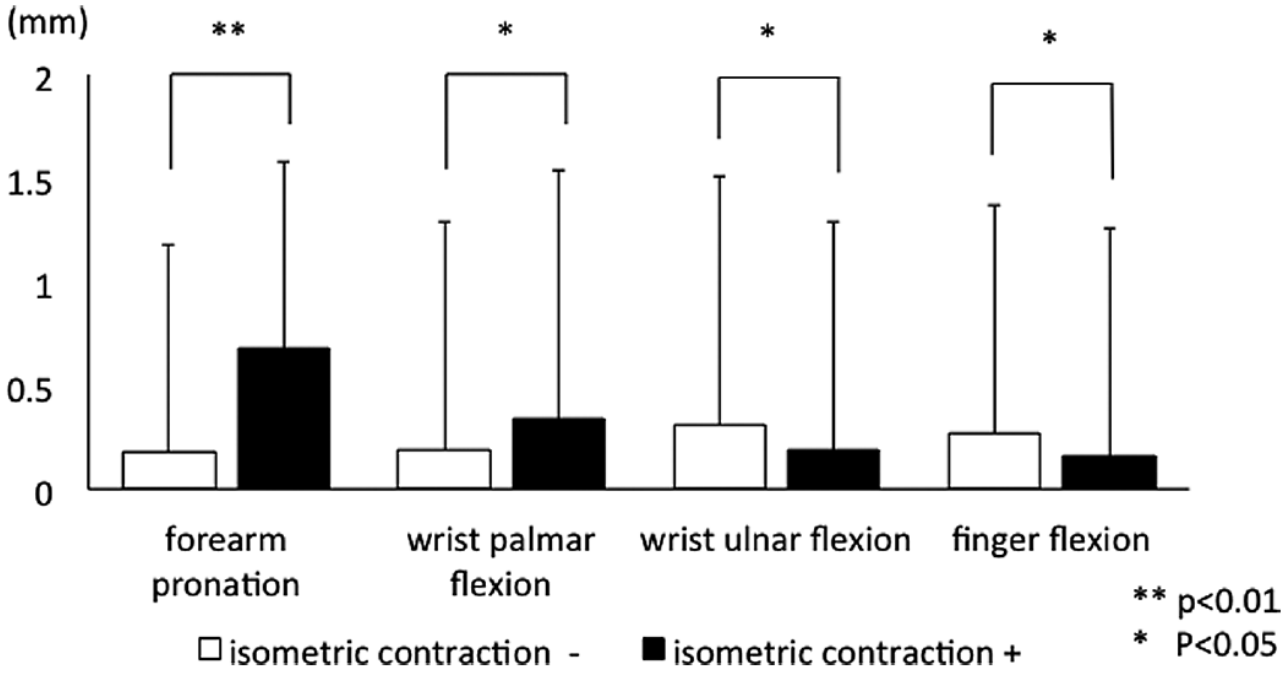
Change of Joint Space



Significantly decrease observed after forearm pronation, wrist palmar flexion, and finger flexion

Ultrasonographic Study

Change of ST Medial Shift



Significant medial shift observed after forearm pronation, and wrist palmar flexion

Ultrasonographic Study

Summary of Results

- ✓ *Joint space was significantly decreased during forearm pronation, wrist palmar flexion, and finger flexion*
- ✓ *ST was significantly shift medially during forearm pronation and wrist palmar flexion*
- ✓ *Maximum change was observed after forearm pronation*

Discussion

New Findings

- ✓ *Anatomical feature of*

  FPMs common tendons

- ✓ *Anatomical & functional features of*

  Pronator teres (PT)

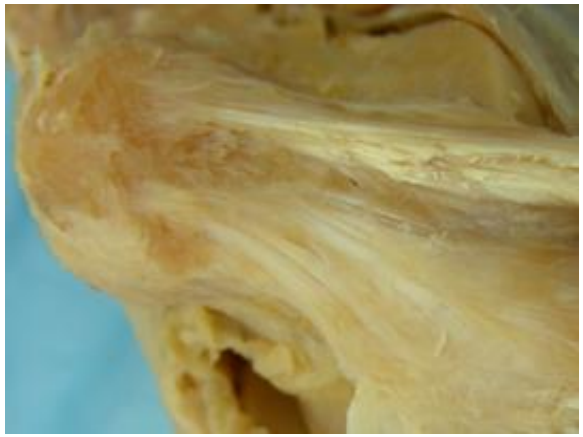
Role of FPMs Common Tendons

- ✓ *Tensioned by FPMs contraction*

Dynamically stabilize by tensioning joint capsule?

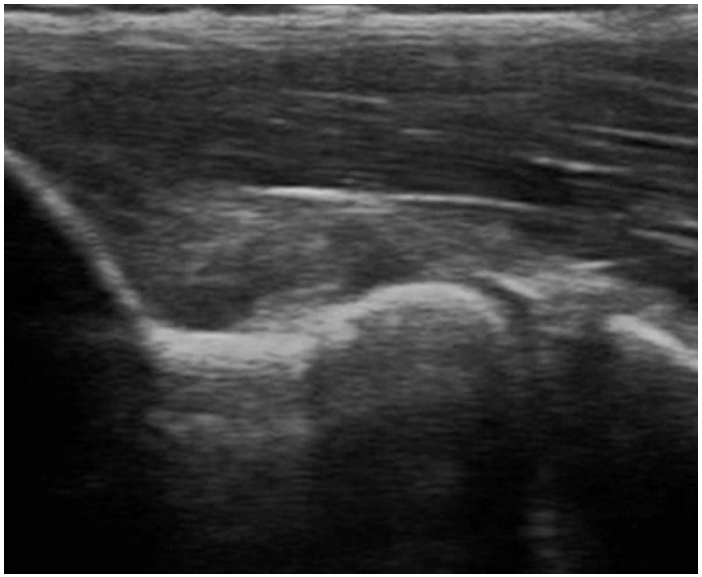
- ✓ *Ligamentous structure of ACT*

Statically stabilize in common with the MUCL?


Role of PT

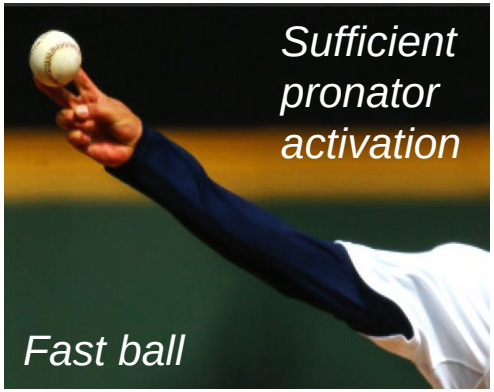
PT (ulnar head) contraction might have a potential to
narrow the joint space directly

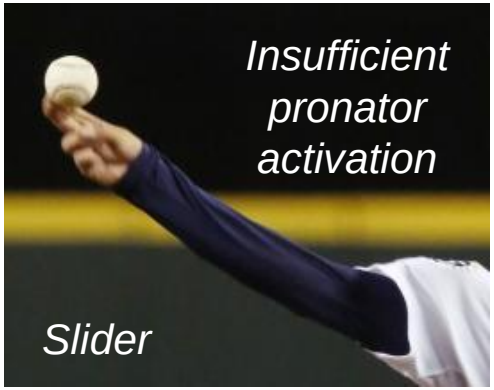


Functioned as main dynamic stabilizer?

Importance of Forearm Pronator in Pitching (Our Hypothesis)

Some pitchers compliant medial elbow pain only when they pitch a "Slider" in clinical situation





✓ *PT had decreased activity in pitchers with MUCL insufficiency*
Grousmann RE AJSM 1992

✓ *Maximum dynamic stabilizing effect was observed in forearm pronation*
Our studies

Sufficient pronator activation could reduce the burden on MUCL

Clinical Application

Concentric and Eccentric

forearm pronation exercise

Conclusion

- ✓ *FPMs could function as both static and dynamic stabilizer against elbow valgus stress.*
- ✓ *PT might play the most important role as a dynamic stabilizer among each FPMs*