



Outline Ligament anatomy Science of proprioception BREAK - 10:45-11:00 Clinical case reports LUNCH 12:15-13:00 Peripheral nerve entrapment algorithm and diagnosis

- BREAK 14:00-14:15
- General discussion Q&A



Ligament Anatomy

- Ligament [Lat 14th century]: "-to bind, tie"
- Connective tissue binding bone to bone to provide stability to a joint
- Static function in joint stability



Background

- Ligaments not only bind, they sense
- Proprioceptive function
- Solomonow: "Major sensory organs"
- Excitatory and inhibitory reflex arcs to control joint motion
- Dynamic and static function of wrist ligaments



Solomonow, J Electrom Kines, 2006 Hagert, PhD thesis, Karolinska Inst, 2008



Scapholunate ligament

Hita-Contreras et al J Anat, 2012

Development

- Orientation of ligaments result of motion of mesenchyme in various directions
- Intrinsic ligaments within the carpus form around week 9
- Created from interzonal mesenchyme



Development

- Orientation of ligaments result of motion of mesenchyme/ capsule in various directions
- Intrinsic ligaments form around week 9
- Created from interzonal mesenchyme
- Extrinsic ligaments connecting forearm and carpus- form around week 10-14
- Created from condensations of joint capsule









Radial "collateral" ligaments Guides the scaphoid, important in DTM





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Midcarpal Pivot-Shift test (Lichtman)

Important static stabilizers of the radiocarpal joint



Marc Garcia-Elias MD PhD



DORSAL LIGAMENTS



DRC

Courtesy of Dr Garcia-Elias

Courtesy of Dr Slutsky

Longest ligaments "Lateral-V construct" DRC: Stability of the wrist in flexion-pronation DIC: Transverse stability of the proximal carpal row Stability of the dorsal midcarpal space



Epifascicular

Golgi-like receptor Posterior midcarpal instability

Loose fascicular ligaments with rich innervation Only ligaments w Golgi-like receptors Important in detecting extremes of joint movement DIC laxity/rupture - dorsal midcarpal instability

DORSAL LIGAMENTS



INTEROSSEOUS LIGAMENTS





Posterior drawer's test

Courtesy of Dr Garcia-Elias

Intrinsic ligaments Stabilize the proximal carpal row Injuries are prevalent

Proprioception.key - 23 oktober 2015



SCAPHOLUNATE INJURY





Proximal row instability DISI deformity Most common ligament injury in the wrist Therefore subject to many studies and publications

SCAPHOLUNATE INJURY













SCAPHOLUNATE INJURY





Proximal row instability DISI deformity

PROPRIOCEPTIVE DEFICITS

PASSION



πάσχω



Gr: paskho "to suffer"











The conscious and unconscious perception and regulation of posture and motion through stimuli originating from receptors in skin, joints and muscles

Sir Charles Scott Sherrington, 1906































Innervation studies

· WRIST:

- Petrie JHS(B) 1997; Hagert CTO 2004; Hagert JOS 2005; Hagert JHS (Am) 2007; Tomita JHS (Am) 2007; Mataliotakis JHS (Am) 2009
- · DRUJ:
 - Ohmori JHS (Br) 1998; Cavalcante JHS (Am) 2004; Shigemitsu Anat Sci 2007
- TMJ:
 - Hagert JHS (Am) 2012; Ladd/ Hagert JBJS 2012



Ν



RUFFINI RECEPTOR







Angelo Ruffini, 1890

ee, Ladd, Hagert. CTO 2011.

Static joint position

dendritic nerve endings slowly adapting - signaling joint position and velocity - static receptor most common mechanoreceptor in the wrist



TYPES OF MECHANORECEPTORS



Ruffini Receptor

corpuscle

Golgi-like receptor

static joint position - velocity

dynamic - acceleration/deceleration extremes of joint motion



Hagert E, Garcia-Elias M, Forsgren S, Ljung B-O. J Hand Surg (Am) 2007



































Importance of preserved joint innervation?

- · Preserve proprioception
 - PIN block alters wrist ligamento-muscular reflexes Hagert and Persson, J Hand Surg Am 2010
- · Ligament healing
 - Denervated joints loose nerve endings and vessels, have altered mRNA expressions and ultimately a reduce healing capacity
 lvie et al, J Orthop Res 2002 Frank et al, J Musculosk Neur 2004
- · Prevent osteoarthritis
 - Denervated joints have a greater risk of OA Salo, Can J Surg 1999; J Orthop Res 2002



Anatomically Sound Surgical Approaches to the Wrist

Goal:

Preserve innervation while providing adequate exposure to the wrist

Hagert, Ferreres, Garcia-Elias J Hand Surg (Am) 2010;35:1070-4.

Garcia-Elias, Hagert Hand Clin 2010;26(4):477-83.

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ages	Plan	Purpose	Technique	Assessmen
1	Basic rehabiliation	Oedema/pain control Motion	Basic hand therapy	VAS ROM

WRIST PROPRIOCEPTION PROTOCOL

1	Basic rehabiliation	control Motion	therapy	ROM
2	Proprioception awareness	Conscious joint control	Mirror therapy	VAS ROM
3	Joint position sense	Replicate joint angle	Blinded Passive/active	Goniometer, joint angle
4	Kinesthesia	Sense joint motion	Motion detection Machine - manual	TTDPM
5	Conscious neuromuscular rehab	Train specific muscles to enhance	Isometric Co-activation	Strength Stability
6	Unconscious neuromuscular rehab	Reactive muscle activation	Perturbation training (machine,	EMG
	Jou	rnal of Hand Ther	ару 2010	



Stages	Plan	Purpose	Technique	Assessment
1	BasStagelia	Oedema/pain Basic hand Motion	l rehabilita	tion _{Rom}
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3	Stage 2 -	Consciou awarei	s proprioc	eptioner, joint angle
4	Kinesthesia			
5	Conscious ne Stage u 3 ° - rehab	Train specific Consciou enhance	s neuromu	scular
6	Stage 4 -	Unconscie	Perturbation DUS neuror	nuscular

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Lun	dborg and Rosén, "Hand f	iunction after nerve repo	air". Acta Physiol 2007;	(189):207-17.



Immediate awareness of joint function





Wide Awake Wrist Surgery - Hagert & Lalonde Hagert, Lalonde. J Wrist Surg 2013

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Conscious neuromuscular rehabilitation



courtesy of Fernanda Coscueta, Argentina

Proprioception.key - 23 oktober 2015

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5	Stage 3.	- Consciou	s neuromus	
6	Stage 4	- Unconscie	ous neuron	nuscular





"In theory, theory and practice are the same. In practice, they are not."

Albert Einstein





CASE

54-year old female teacher, sustained a distal radius fracture after fall on ice. Xray showed initial dorsal displacement and concomittant ulnar styloid fracture. Responded well to treatment with closed reduction and cast. Xray control after 10 days showed slight increase in dorsal displacement, but was still judged as treatable conservatively. The patient was instructed to remove the cast after 4 weeks at her primary care physician. 3 weeks after removal of the cast, she seeks assistance in the hand surgery clinic due to poor motion.

In the clinic, the patient keeps her hand in a sling. The hand is inspected with swelling, increased palmar sweating and poor motion not only in the wrist but in the fingers as well. Wrist ROM, ext/flex 20/10, rad/uln dev 5/10, pro/supination 60/-10.

DIAGNOSIS? TREATMENT? PROPRIOCEPTION STRATEGIES?

In the clinic, the patient keeps her hand in a sling. The hand is inspected with swelling, increased palmar sweating and poor motion not only in the wrist but in the fingers as well. Wrist ROM, ext/flex 20/10, rad/uln dev 5/10, pro/supination 60/-10.

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1	Basic rehabiliation	Oedema/pain control Motion	Basic hand therapy	VAS ROM





Karagiannopolous, Sitler, Michlovitz, Tierney

Studying the effects of DRF and proprioception Pain significantly influences proprioceptive acuity and sensorimotor function

J Hand Therapy, 2013. 26 (3):204-14





Stages	Plan	Purpose	Technique	Assessment
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2	Proprioception awareness	Conscious joint control	Mirror therapy	VAS ROM
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Altschuler and Hu, "Mirror training in patient with fractured wrist..". Scand J Plast Reconstr Hand Surg 2008



MIRROR THERAPY - PAIN AND PAINFREE?



Frequently used for pain and stroke patients Pain-free patients with hand injuries - Improved ROM + DASH Largest RCT on mirror-therapy Rostami et al; Disabil Rehab, 2013

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PROPRIOCEPTION & PAIN



Karagiannopolous, Sitler, Michlovitz, Tierney JOINT POSITION SENSE WAS MOST AFFECTED IN DRF PATIENTS! J Hand Therapy, 2013. 26 (3):204-14



Karagiannopolous, Sitler, Michlovitz, Tierney JOINT POSITION SENSE WAS MOST AFFECTED IN DRF PATIENTS! J Hand Therapy, 2013. 26 (3):204-14





Ulnar wrist ligaments - proprioceptive function contributing to neuromuscular stability

Free nerve endings predominate in TFCC (Rein, Garcia-Elias, Lluch, Hagert 2014)

Explains common ulnar sided wrist pain?



Stages	Plan	Purpose	Technique	Assessment
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MUSCLES?				

Tendinous/muscular compression

- Secondary, dynamic stability of the ulnar wrist
- Pronator quadratus primary stabilizer of the DRUJ



Tendinous/muscular compression

- Pathoanatomy includes:
 - scarring following distal radius fx - will affect pronosupination
 - atrophy following AIN palsy may affect DRUJ stability



DRUJ









Susanne Rein MD PhD

Golgi - subsheath

Innervation of TFCC and surrounding tissues Golgi-like receptors in subsheath indicate proprioceptive link TFCC - ECU (Rein, Semisch, Garcia-Elias, Lluch, Hagert - FESSH 2014)

Tendinous/muscular compression

- ECU important for ulnar motion and stability
- Common source of ulnar sided wrist pain



MATERIAL

subsheath of the extensor carpi ulnaris (SS-ECU) meniscoid (M) ulnotriquetral ligament (UTqL) ulnolunate ligament (ULL) triangular disc (TD) volar radioulnar ligament (VRUL) dorsal radioulnar ligament (DRUL)







images courtesy of Dr Susanne Rein

DISTRIBUTION MECHANORECEPTORS



CONCLUSIONS

- Radioulnar ligaments greatest mechanoreceptor populations
- Important proprioceptive function
- Golgi receptors in the ECU subsheath and radioulnar ligaments
- Sensing extremes of rotation motions
- Free nerve endings most common nerve ending
- UTq-Meniscoid
- Explains ulnar wrist pain!



DISTRIBUTION FNE - VESSELS



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	Basic rehabiliation	Oedema/pain control Motion	Basic hand therapy	VAS ROM
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HOW TO TRAIN?				

CROSS EDUCATION

Neural adaptation defined as the increase in strength or functional performance of the untrained contralateral limb after unilateral training the opposite (uninjured) limb





CROSS EDUCATION RCT

- **AIM**: improving strength and mobility following distal radius fractures
- **Control group**: standard rehabilitation
- **Training group**: standard rehabilitation of non-injured hand immediately post-fracture
- RESULT: Strength training the non-fractured limb after a distal radius fracture = improved strength and ROM in the fractured limb after cast removal until 12 weeks

Magnus CR et al; Arch PM&R, 2013.



EARLY CONTROLLED MOTION



TFCC splint by hand therapist David Engstedt, OT

Wide awake surgery = early controlled active motion!

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HOW TO MEASURE WRIST FUNCTION?				



WRIST MEASUREMENTS?RANGE OF MOTIONJAMARPRVEMAYO WRIST SCORE

ISOP - ISOmetric Power device



Jedeskog U, Hagert E - Physiotherapy Sports Medicine Master Thesis, Karolinska Institutet, 2014

Reliability testing (test - retest) of isometric wrist strength using ISOP 20 volunteers (10 men/10 women) performed max wrist isometric push in all three planes of motion Measurements repeated after 1 week

ISOP (ISOmetric Power device; Tylena Medical Control Group, Malmö, Sweden)



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Could you?

Background

- Basal thumb osteoarthritis (CMC I OA) affects 20-25% of postmenopausal women and >65% of women >80
- Most common cause of OA surgery in the upper extremity
- Proposed causes: hereditary, hyperlaxity and excessive joint loads



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TREATMENT PARADIGM

Stages 3-5 of Hagert

How do therapists treat CMC I OA? Proprioceptive regimes?

O'Brien V, Giveans MR. Effects of dynamic stability approach in conservative intervention of CMC joint of the thumb: A retrospective study.

J Hand Ther 26(1);44-52, 2013.

O'Brien V, McGaha JL. Current practice patterns in conservative thumb CMC joint care: survey results.

J Hand Ther 27(1);14-22, 2014.

O'BRIEN SURVEY

This also pertains to the use of neuromuscular re-education that is a foundational therapeutic intervention technique used to retrain motor patterns in all areas of the body.⁵¹ Only a small portion of therapists reported the use of NMRE in thumb care, Evidence is emerging that a neuromuscular, pain-free approach to learning novel motor patterns is most effective for functional rehabilitation at all joints in all conditions or diagnoses.⁵² Future research needs to confirm if conservative care using a neuromuscular approach significantly reduces pain and disability of patients and maybe beneficial to incorporate in practice for CMCJ issues.^{51,52} Another area for further research investigation is the therapeutic use of modalities.

O'Brien V, McGaha JL. Current practice patterns in conservative thumb CMC joint care: survey results.

J Hand Ther 27(1);14-22, 2014.

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MUSCLES?				



M & M

- 10 cadaver hands w/out OA
- Jig for load and orientation
- 8 different thumb positions
- Testing of extrinsics (EPL, EPB, APL, FPL)
- Testing of intrinsics (APB, OP, FPB, IOD1, AP
- Isometric loading at physiological joint loads (Linscheid et al, Clin Anat, 2001)



Results

- In all thumb positions, the 1st dorsal interosseous was the primary muscle to reduce dorsoradial subluxation
- In all thumb positions, the APL was the primary muscle to induce dorsoradial subluxation
- APL = Significant (p<0.01) changes in motion compared to all other muscles tested
- A synergistic effect of IOD-1 and OP could be noted, but wasn't measured



Conclusions

- IOD1 thumb stabilizer
- APL thumb destabilizer
- Early CMC1 OA exercises to promote IOD1 strength and avoid APL dorsoradial subluxation
- Further studies on thumb proprioceptive reflexes and neuromuscular stability in-vivo
- Effect of synergistic load in normals and patients with CMC1 OA



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HOW TO TRAIN?				

BASALTHUMB EXERCISES



Push finger out to the side to tighten muscle between thumb and index finger

Practice making a "c" to put your thumb in a good posture!

courtesy of Sue Michlovitz, Ithaca, USA



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M&M

- 10 healthy participants, 5 women/5 men, mean age 28
- nr vy mar i Ryes 1
- No previous hand/thumb trauma
- US assisted insertion of needle
 electrode into DRL
- Intramuscular electrodes into two
 extrinsics two intrinsics





HAND FOOT







CONCLUSIONS The DRL is of primary importance in • CMC stability and proprioception Stoutest, most richly innervated, with • ligamento-muscular reflexes DRL DRL-APL close proximity - same • neural innervation DRL-APL reflex loop for fast control -• both inhibitory and excitatory Confirms muscle testing in cadavers! • 3.15 Karolinska Institutet HAND FOOT





A young woman, 17 years old, presents with a history of cluncking wrists. She's a left-handed high school student with extra-articular activities that include dancing, swimming and, recently, badminton. She complains of clunking that has started to become painful since she started with badminton just a couple of months ago. During gymnastics she has always noted a clunking tendency, but without pain. She is supple, with hyperlax joints bilaterally and globally. She has a positive Lichtman test grade II and a tendency for positive posterior drawers test bilaterally, but indicates that the tests are slightly painful in her left wrist, but not her right. Her xrays are normal.



Marc Garcia-Elias MD PhL





Stages	Plan	Purpose	Technique	Assessment
1	Basic rehabiliation	Oedema/pain control Motion	Basic hand therapy	VAS ROM











ourtesy of Dr Alex Lluch

Only the effect of one muscle stadistically counteracted such excessive flexion of the proximal row, the Extensor Carpi Ulnaris.

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Recommended reading

- Riemann, Lephart. "The Sensorimotor System, parts I-II", *J Athl Train 2002. 37(1):* 71-84
- Myers, Lephart. "Role of the Sensorimotor System in the Athletic Shoulder", J Athl Train 2000. 35(3):351-63
- Solomonow. "Sensory-motor control of ligaments and associated neuromuscular disorders", *J Electromyogr Kinesiol 2006.* 16(6): 549-67.
- Hagert. "Proprioception of the Wrist Joint: a Review of Current Concepts", *J Hand Ther 2010. 23(1):2-17.*
- Hagert, Mobargha. "The role of proprioception in osteoarthritis of the hand and wrist", *Curr Rheum Rev 2012.* 8(4):278-284

Karolinska Institutet HAND FOOT

PASSION

Practice makes perfect - but passion makes progress

PASSION

