CTS the Best EDX

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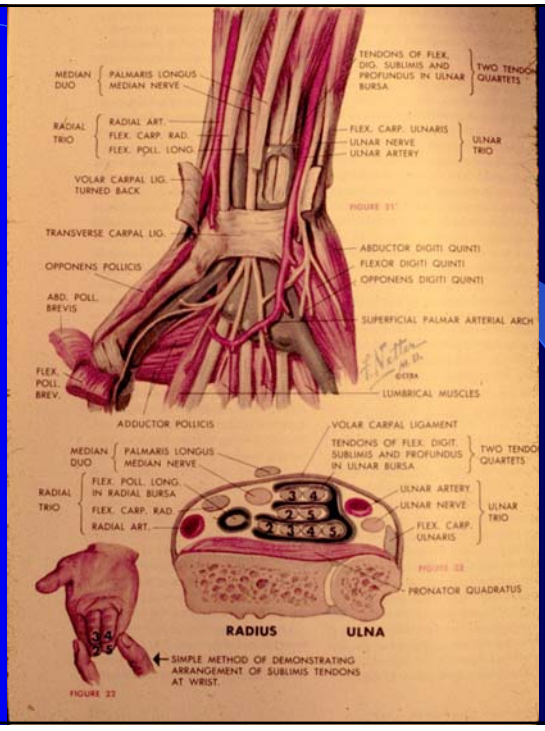
Definition of CTS

- A syndrome 2d to ***dysfunction of median nerve*** in carpal tunnel resulting in:
  - Pain and numbness in the hand
  - Worse on finger activity
  - Aggravated by forceful griping
  - Symptoms more prominent at night

81 y/o lady being treated for ‘arthritis’ for 8 years

Definition of CTS

- Pain and numbness
- Secondary to median in the carpal tunnel
- If there is dysfunction pathology



Signs of CTS - PX

- a) Weakness of thenar muscles
- b) Phalen sign
- c) Tinel sign
- d) Wrist ratio
- e) 2-point discrimination

- Kuhlman & Hennessey found best: d>a>e>b>c

Review of Literature

- Phalen in 1966 reported “no need for EDX in dx of CTS”
- In middle ’50’s Gilliatt noted “EMG and sweating tests are too time consuming for a busy clinic”
- Marinacci (1st text on EMG) used only needle EMG in dx CTS

IN CTS - 3 Things can occur

- Some axons die
- Some axons block
- Some axons slow
- Some are functioning normally
- *Any or all occur in combination*

Demyelination causing Conduction Block

- When median nerve is stimulated at wrist (proximal to carpal tunnel)
  - *Decreased CMAP*
  - *Decreased SNAP*
  - *Decreased CNAP*
- Reduced recruitment with needle EMG

Demyelination in CTS causing slowing

- When stimulated at wrist
  - *Increased latency – motor & sensory*
  - *Decreased amplitude: CMAP: SNAP:CNAP*
  - *Rise time & duration - increased*

Death of Axons is shown

- WHEN median nerve is STIMULATED ***DISTAL*** TO COMPROMISE
- Axon death results in decreased amplitudes:
  - SNAP
  - CNAP
  - CMAP
- Needle EMG – positive waves & fibrillation potentials; reduced recruitment

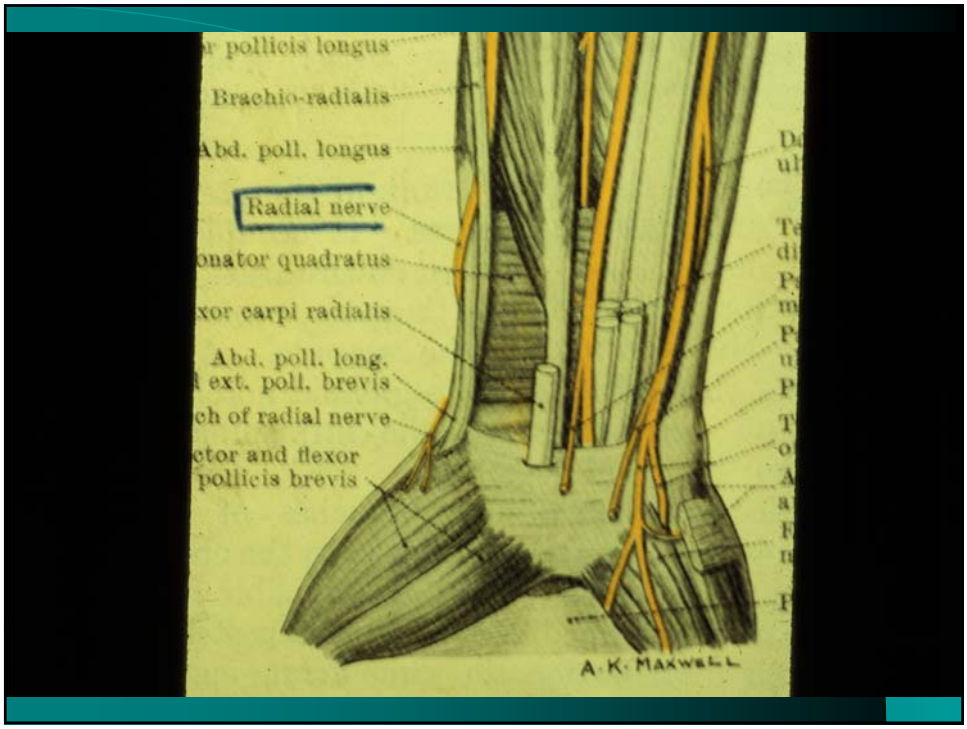
Prognosis

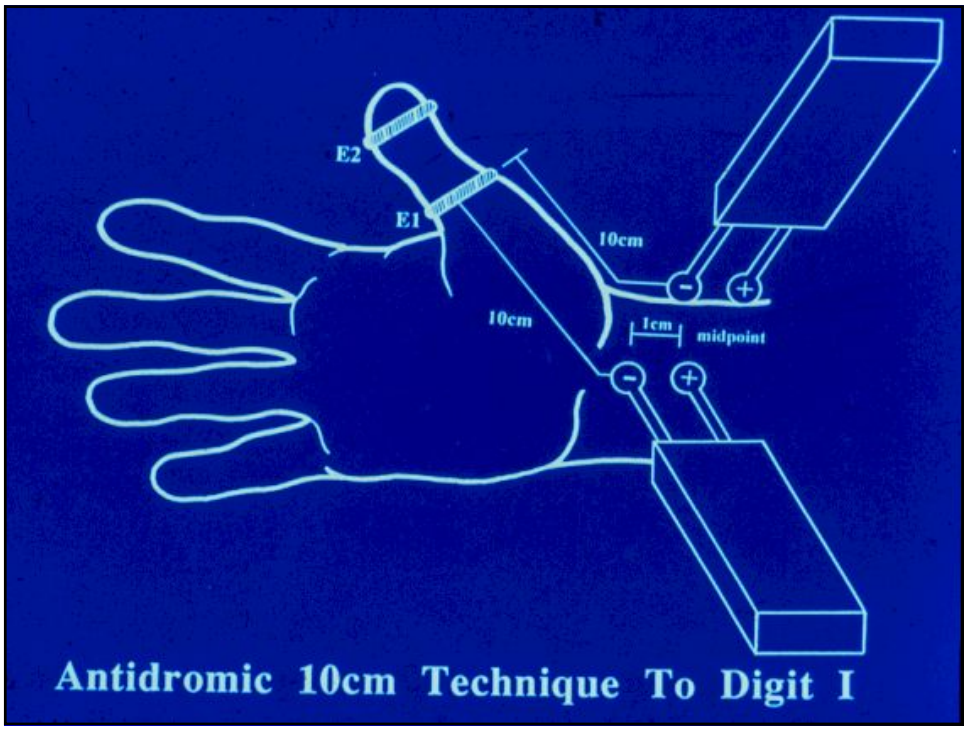
- Not related to latency or fibrillations
- Not related to recruitment
- *DIRECTLY RELATED TO CMAP/SNAP/CNAP AMPLITUDE distal to the carpal ligament*

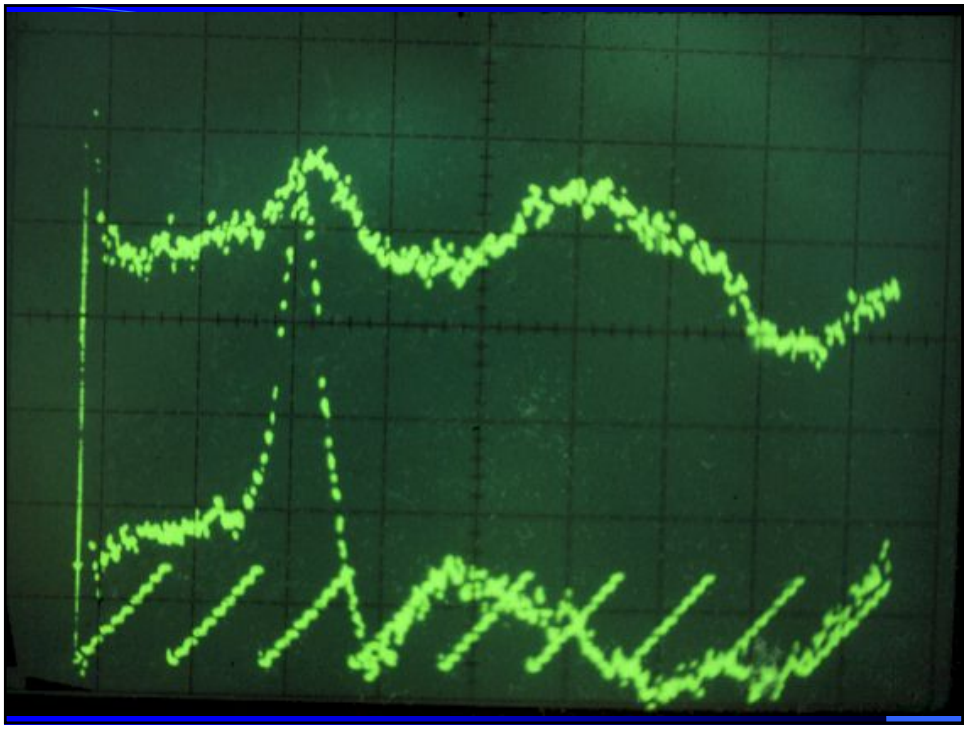
IS THERE edx TO SCREEN FOR cts?

Yes!

And here's How -


pollicis longus
Brachio-radialis
Abd. poll. longus
Radial nerve
onator quadratus
xor carpi radialis
Abd. poll. long.
ext. poll. brevis
ch of radial nerve
ctor and flexor
pollicis brevis
A. K. MAXWELL


E2
E1
10cm
10cm
1cm
midpoint
Antidromic 10cm Technique To Digit I



Screen for CTS

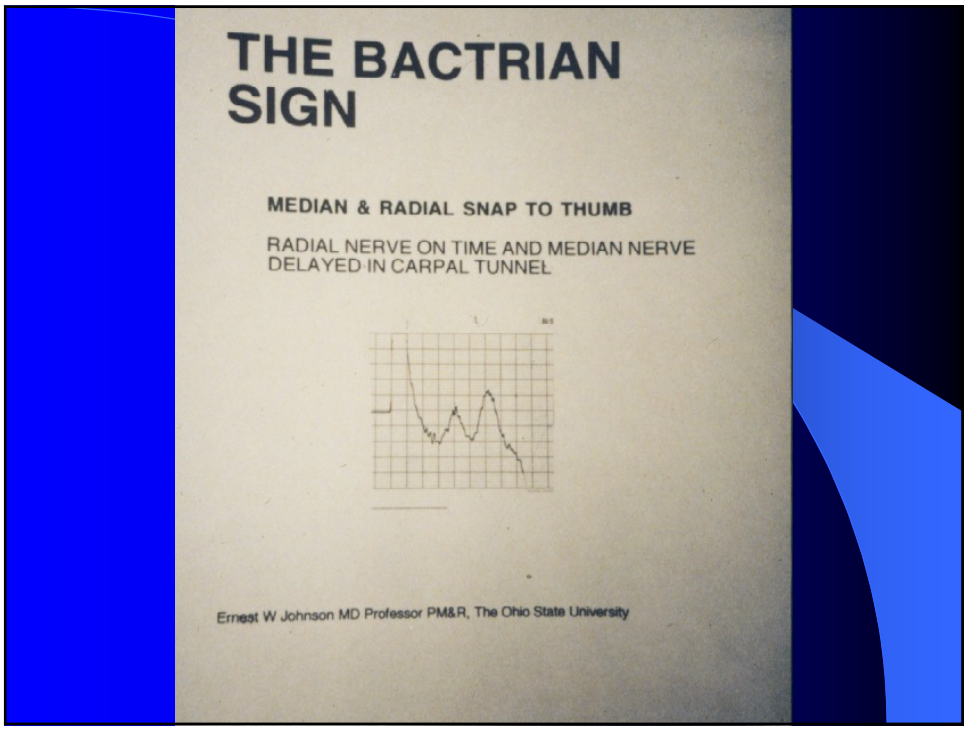
- Median & radial nerves to dig 1
- 95% of latencies will differ by =/<.3 ms
- Note amplitude will be 3:1 median to radial
  - Sum will be >25 uV* (if less and latency is normal – consider neuropathy or spinal nerve compromise distal to dorsal ganglion)

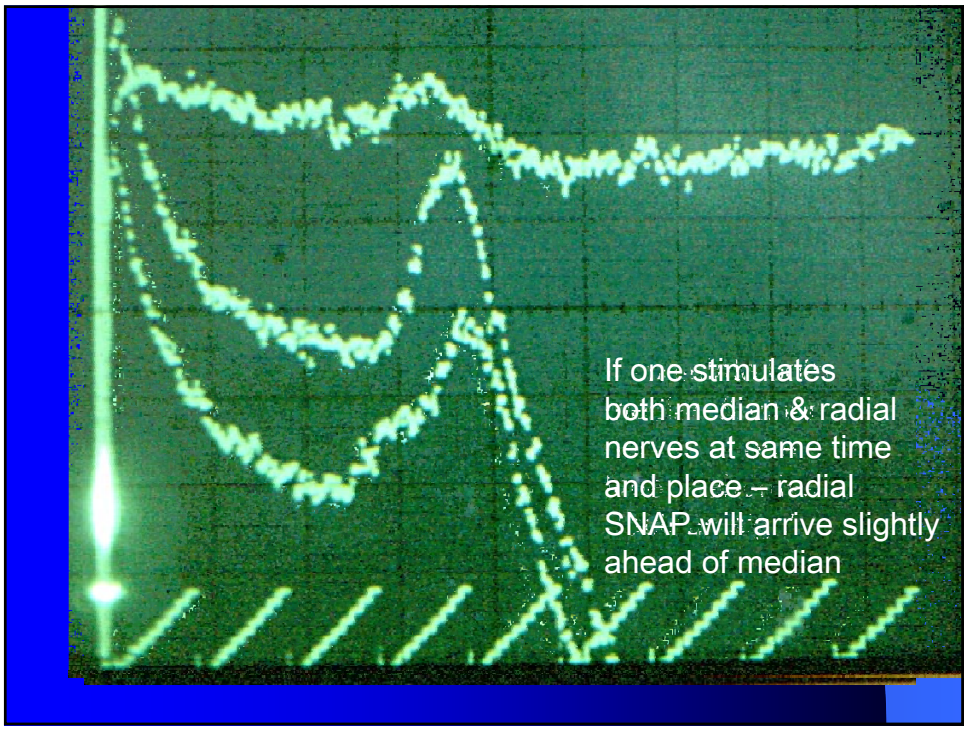
*'Pannozzo index'

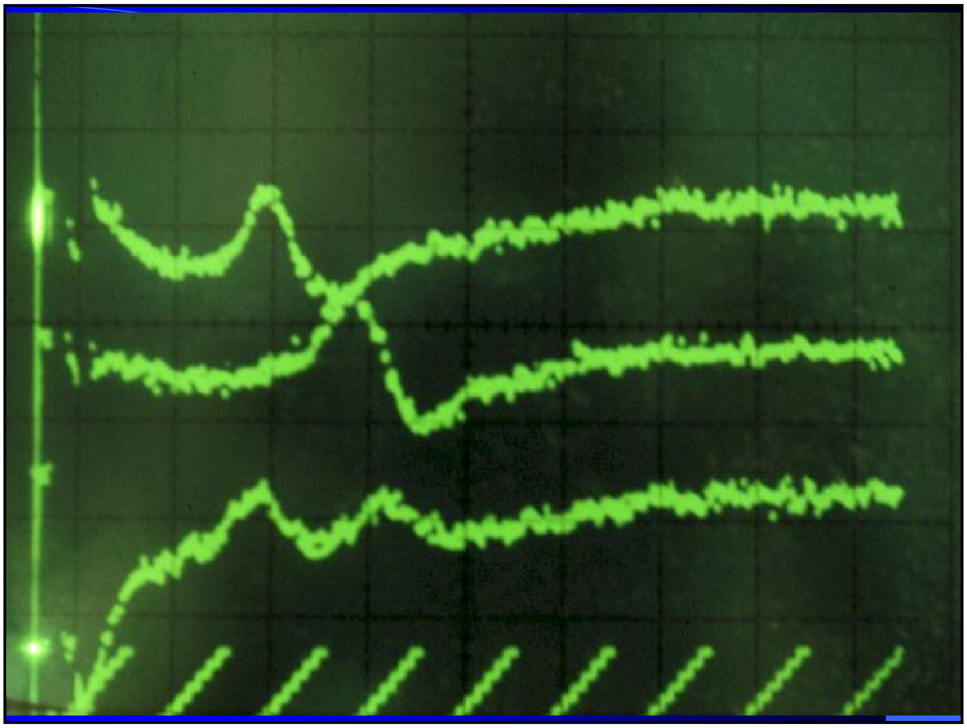
Reference values for dig 1

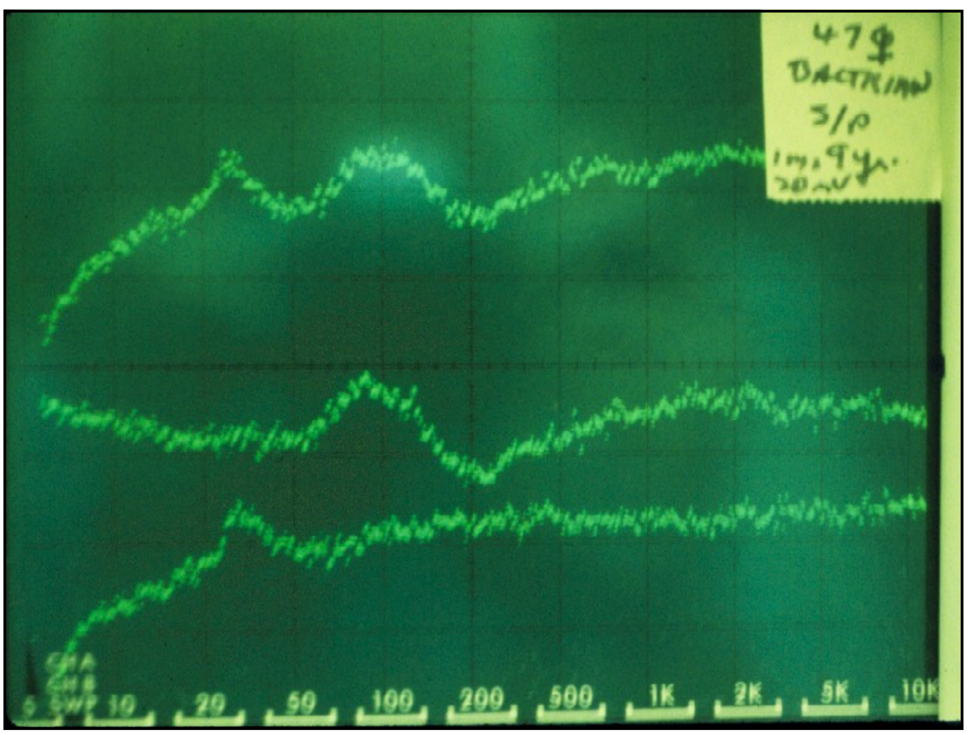
N= 78	latency (ms)	ampl. (uV)
Median n.	2.59 +/- .24	30.4 +/- 1.9*
Radial nerve	2.44 +/- .23	11.6 +/- .6*

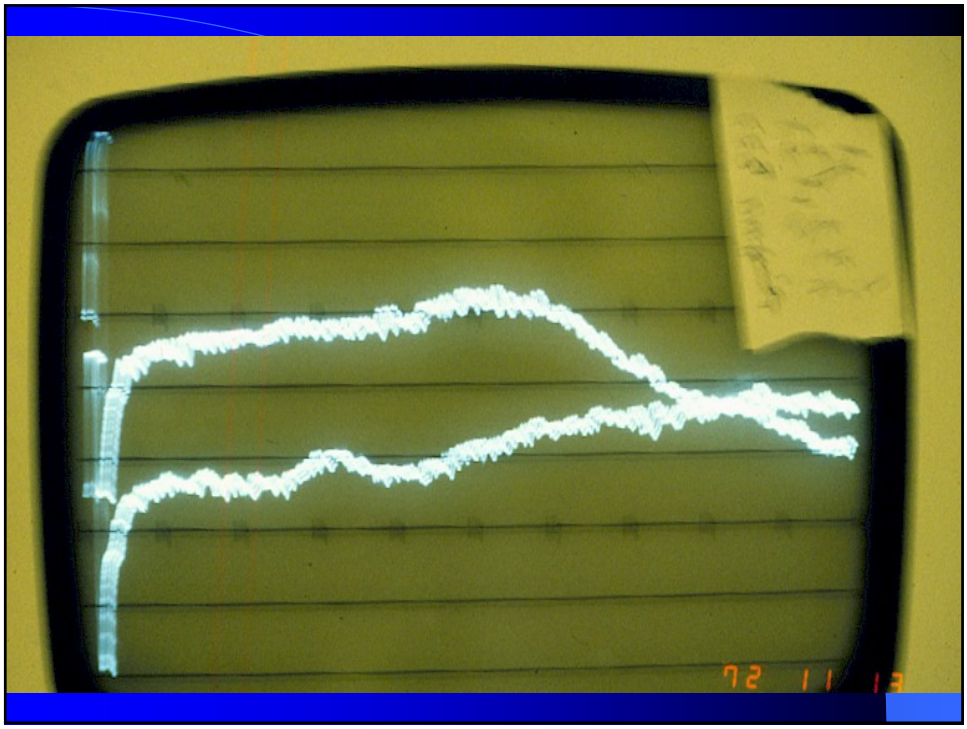
- 95% difference =/< .3 ms
- *'Pannozzo Index – total =/< 25uV

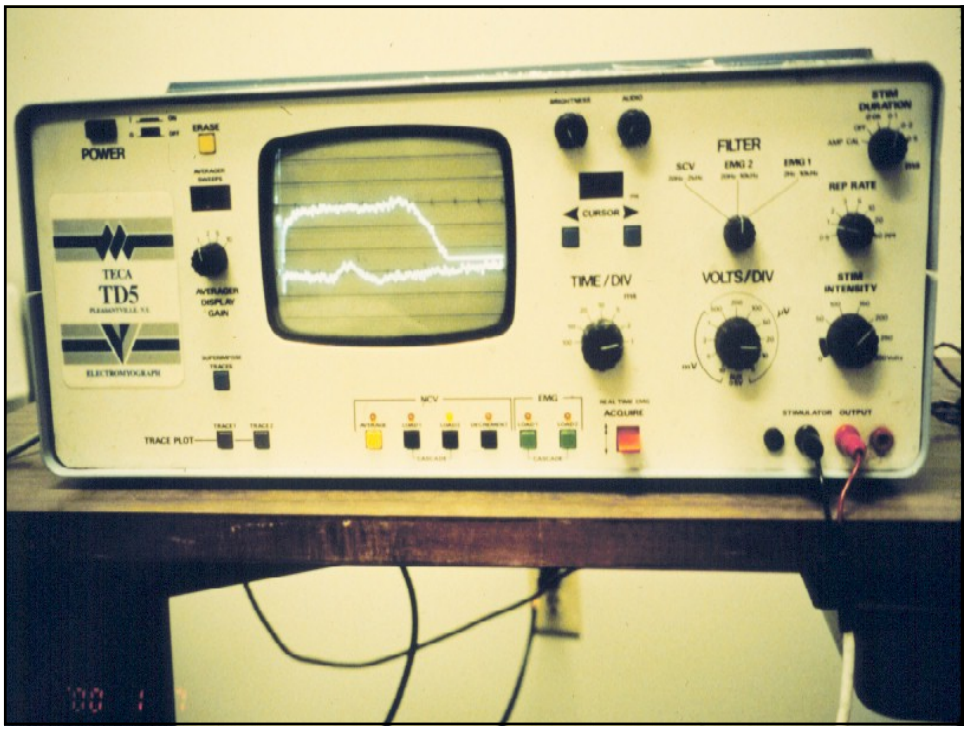



If one stimulates both median & radial nerves at same time and place – radial SNAP will arrive slightly ahead of median




47 ♀
BACTRIAN
S/P
CH A
CH B
SWP
10
20
50
100
200
500
1K
2K
5K
10K

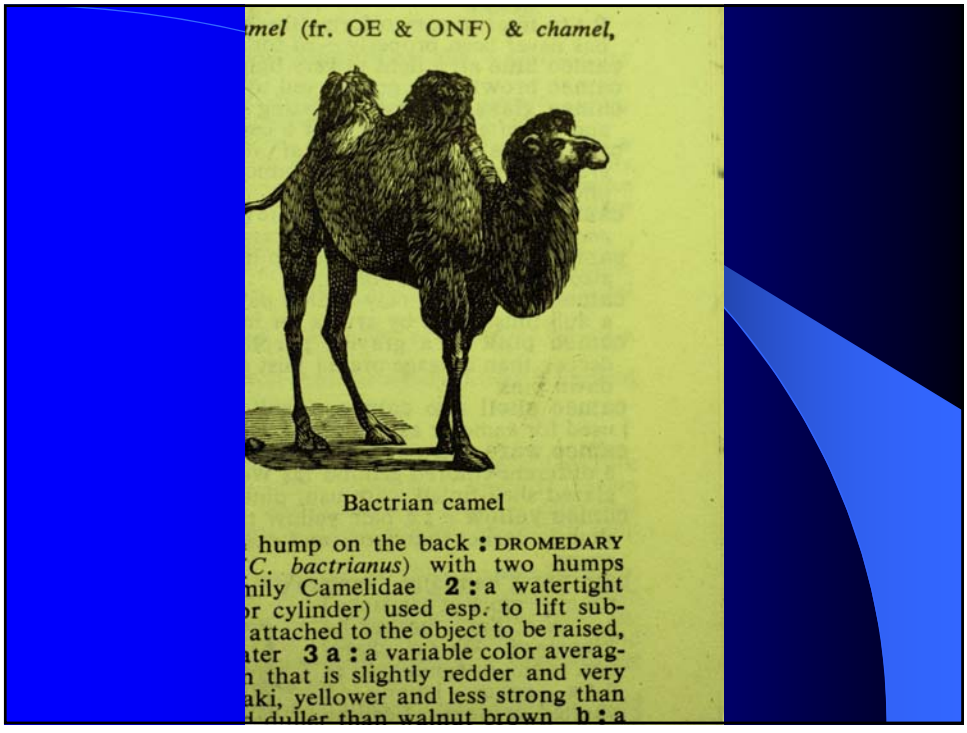



POWER
ERASE
TECA
TD5
ELECTROMYOGRAPH
CURSOR
FILTER
SCV
EMG 2
EMG 1
REP RATE
TIME / DIV
VOLTS/DIV
STIM INTENSITY
STIM DURATION
TRACE PLOT
ACQUIRE
STIMULATOR OUTPUT

Bactrian Sign

NB. Dur
Of SNAP
Is <2ms

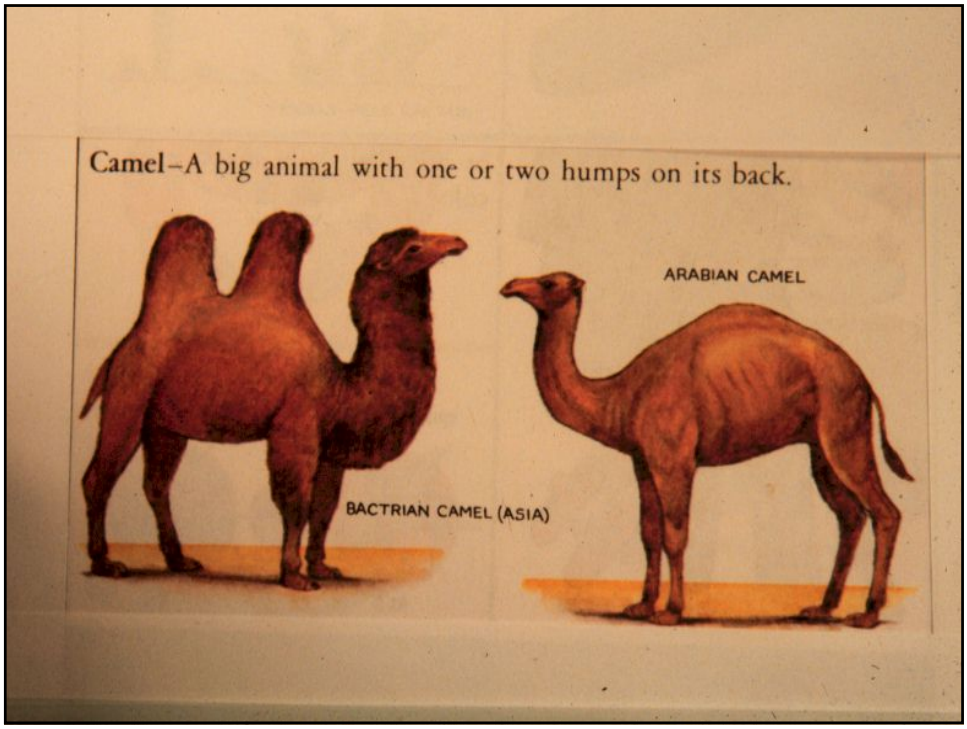
20.0 μV 1 ms



…mel (fr. OE & ONF) & *chamel*,

Bactrian camel

… hump on the back : DROMEDARY
(*C. bactrianus*) with two humps
…mily Camelidae **2 :** a watertight
…r cylinder) used esp. to lift sub-
… attached to the object to be raised,
…ter **3 a :** a variable color averag-
…n that is slightly redder and very
…aki, yellower and less strong than
… duller than walnut brown **b :** a



How to Tell a Camel

The **D**romedary has one hump,

The **B**actrian has two.

It's easy to forget this rule,
So here is what to do.
Roll the first initial over
On its flat behind:

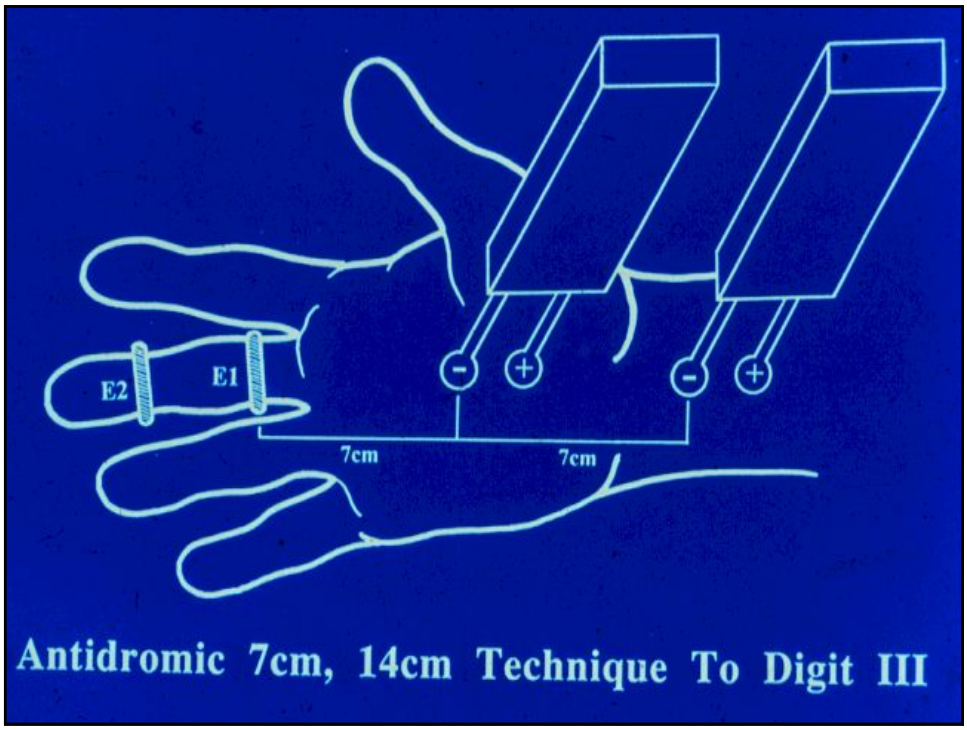
The **B**actrian is different from

The **D**romedary kind.

—*J. Patrick Lewis*

Next step – Long finger

- Best to stimulate at 7 cm and 14 cm antidromic (*NB. Proximal & distal to CT*)
- Distal latency will be >1/2 of total
  - Distal nerve is narrower
  - Distal hand is cooler
- This is longest portion of median nerve

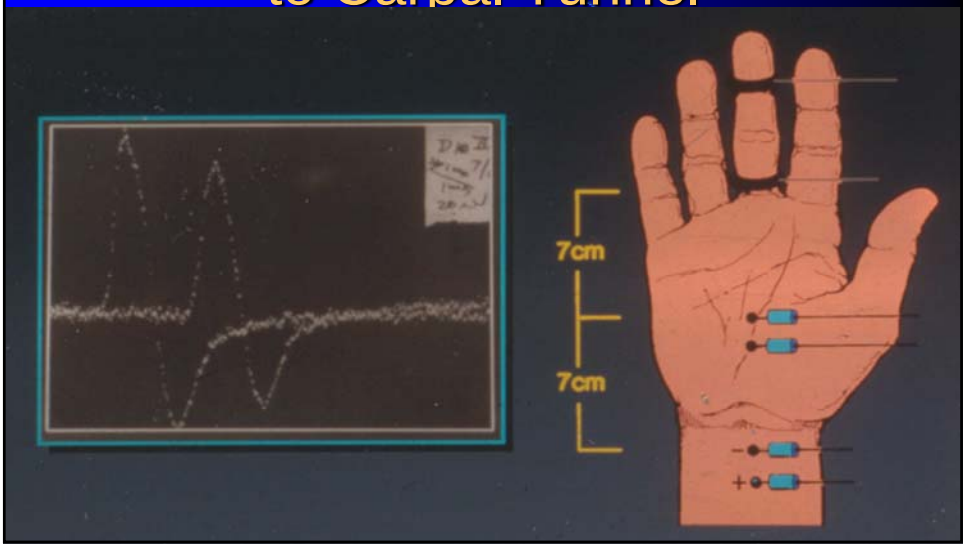


Antidromic 7cm, 14cm Technique To Digit III

Dig 3 SNAP 7 & 14 cm

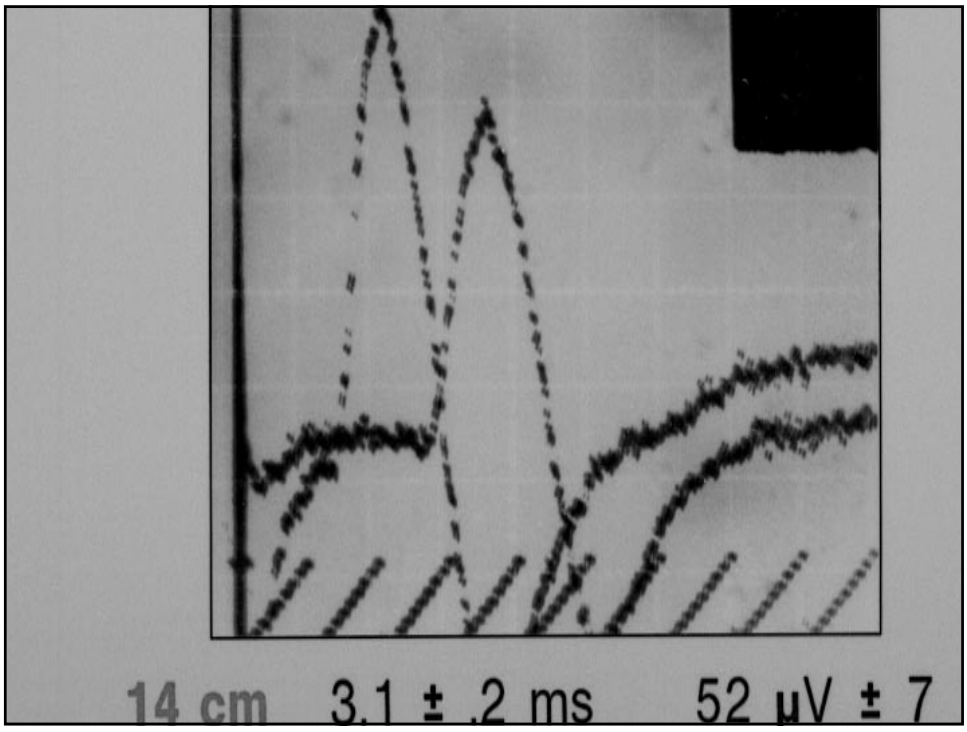
- Mean latency 1.6 ms; 3.1 ms (+/- .3ms)
- Mean amplitude 50 uV; 40 uV
- Cold increases amplitude and latency
- NB. Patients with Raynaud phenomenon or over-active sympathetics will have marked increases in ampl & latencies

Stimulation Proximal & Distal to Carpal Tunnel

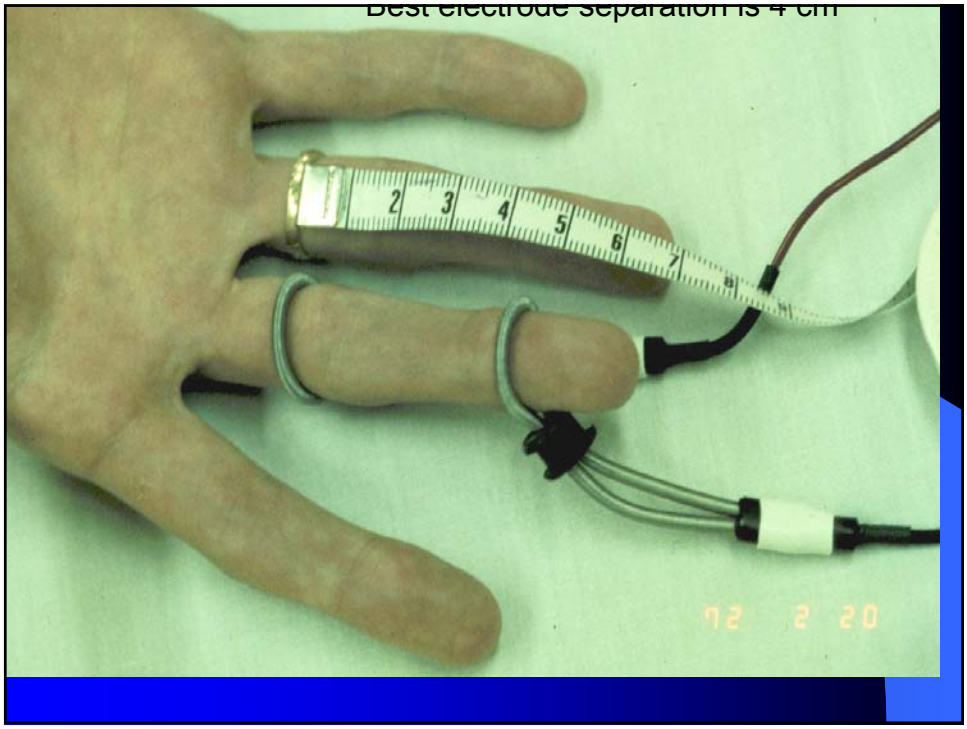


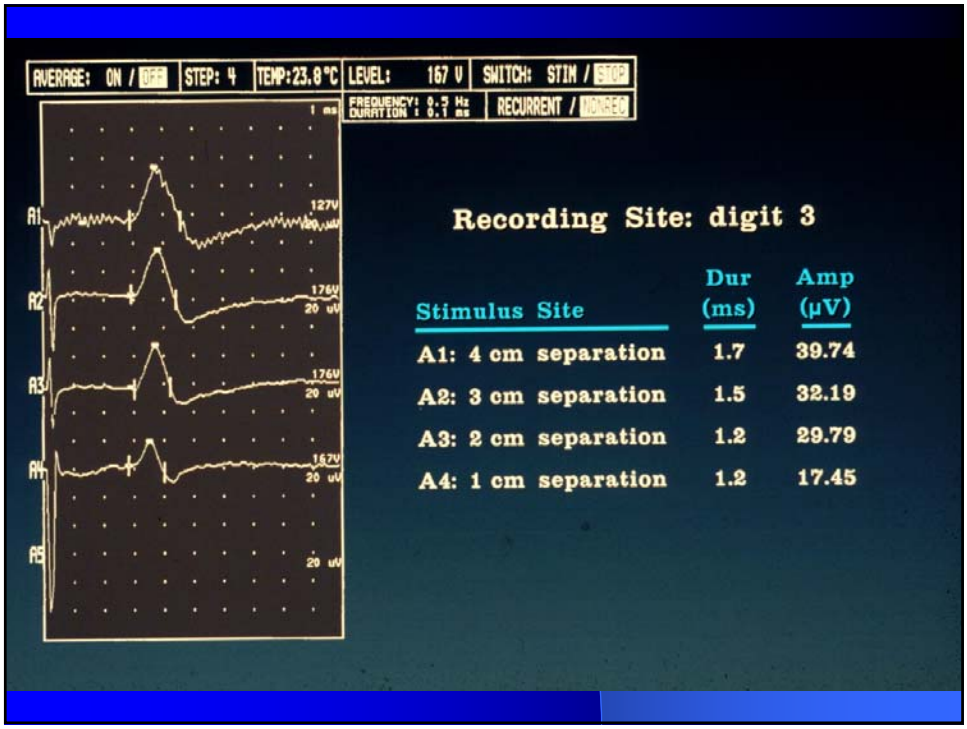
Cool hand will change ratio of latencies distal and proximal

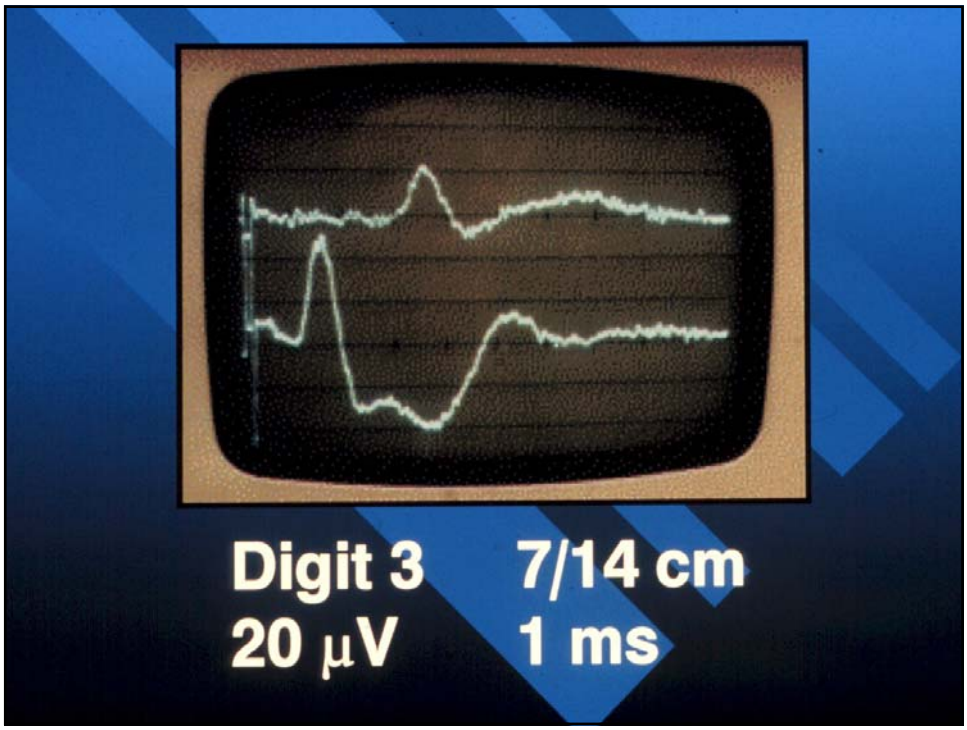
- Normal – distal 7 cm is slightly more than ½ (smaller diameter and cooler)
- If hand is very cool (sympathetic ++), the proximal latency can cover up the mild CTS.
- Cool hands will increase amplitudes and durations as well as latencies.

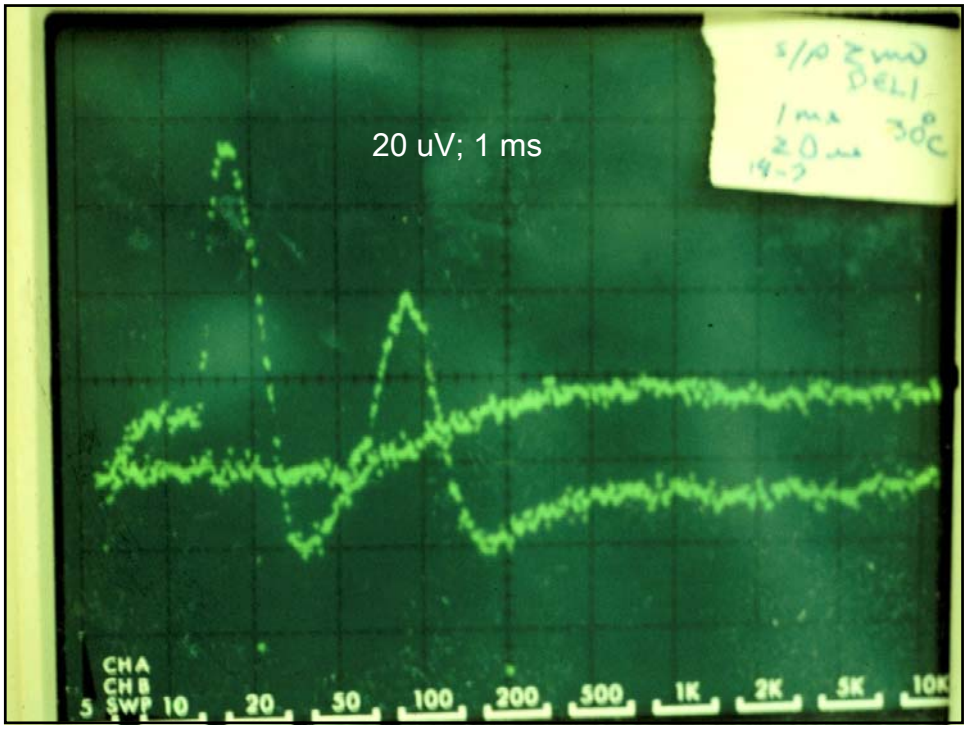


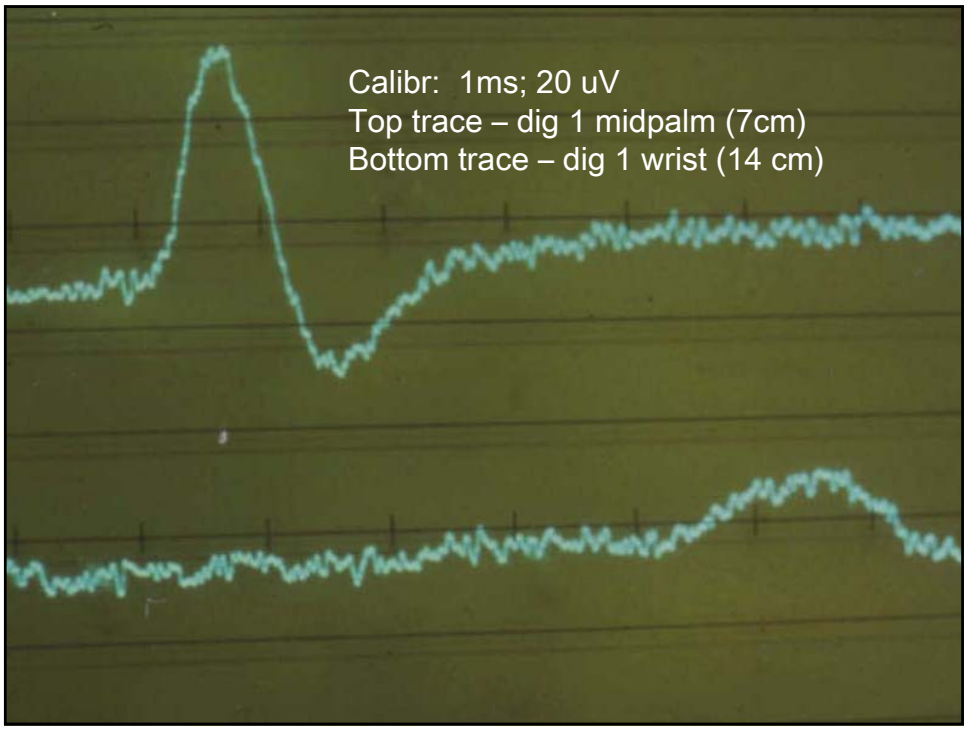
Best electrode separation is 4 cm

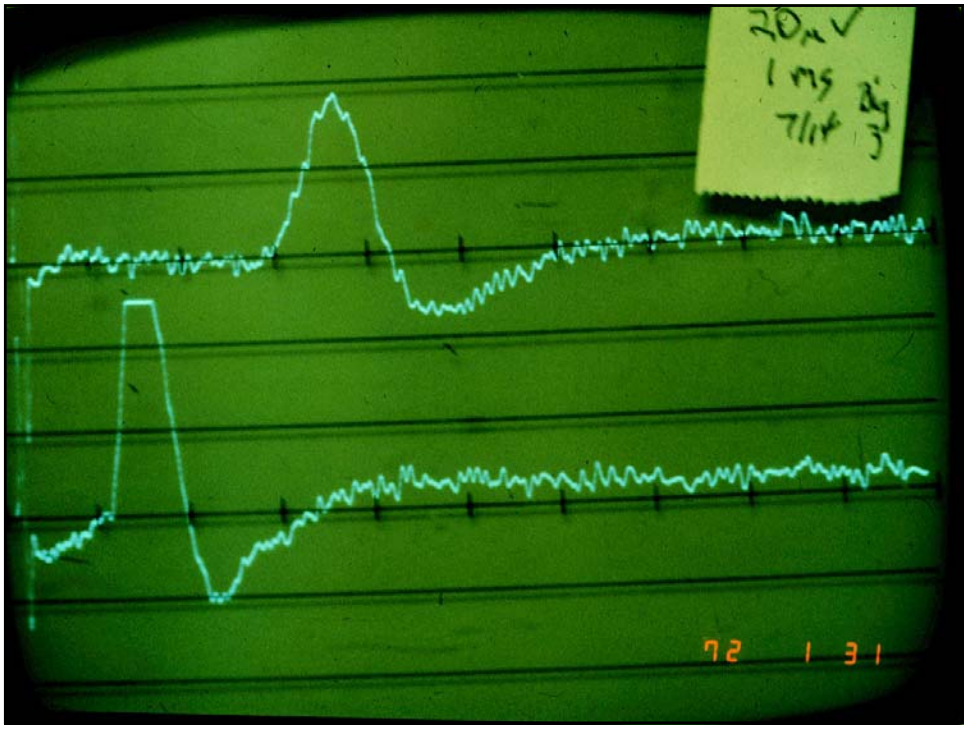



AVERAGE: ON / OFF
STEP: 4
TEMP:23.8°C
LEVEL: 167 V
SWITCH: STIM / STOP
FREQUENCY: 0.7 Hz
DURATION : 0.1 ms
RECURRENT / NUMBER
1 ms
A1
A2
A3
A4
A5
127V
176V
20 uV
176V
20 uV
167V
20 uV
20 uV
Recording Site: digit 3
Stimulus Site
Dur (ms)
Amp (μV)
A1: 4 cm separation 1.7 39.74
A2: 3 cm separation 1.5 32.19
A3: 2 cm separation 1.2 29.79
A4: 1 cm separation 1.2 17.45

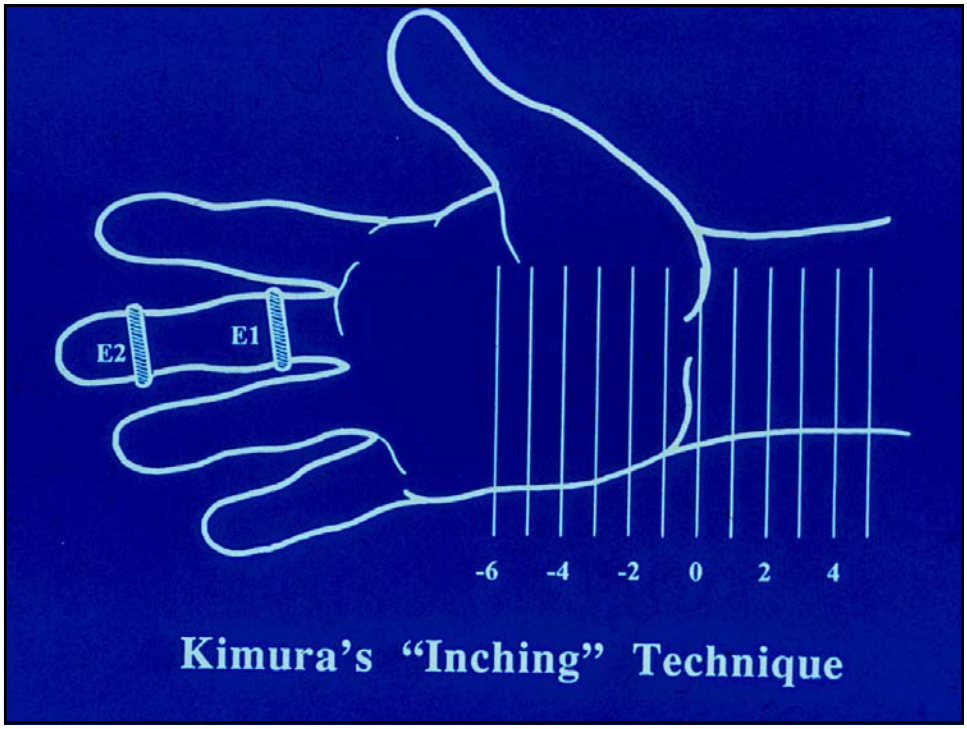

Digit 3 7/14 cm
20 μV 1 ms


20 uV; 1 ms
CHA
CHB
SWP
10
20
50
100
200
500
1K
2K
5K
10K


Calibr: 1ms; 20 uV
Top trace – dig 1 midpalm (7cm)
Bottom trace – dig 1 wrist (14 cm)

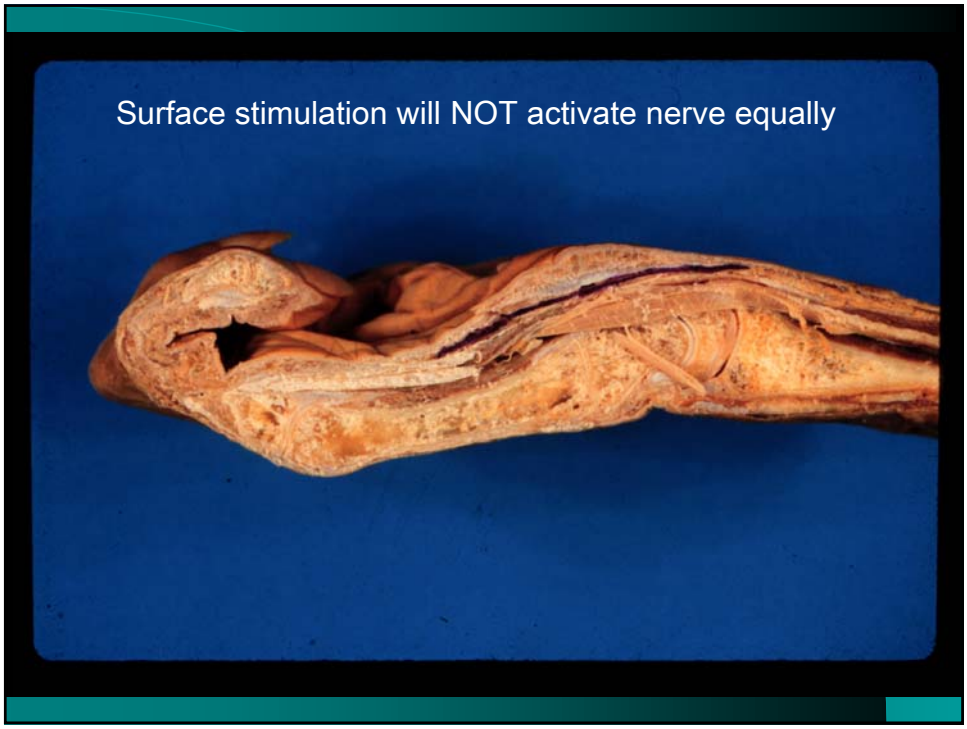

20mV
1 ms
7/14 Dig 3
72 1 31


7/14 cm Digit 3



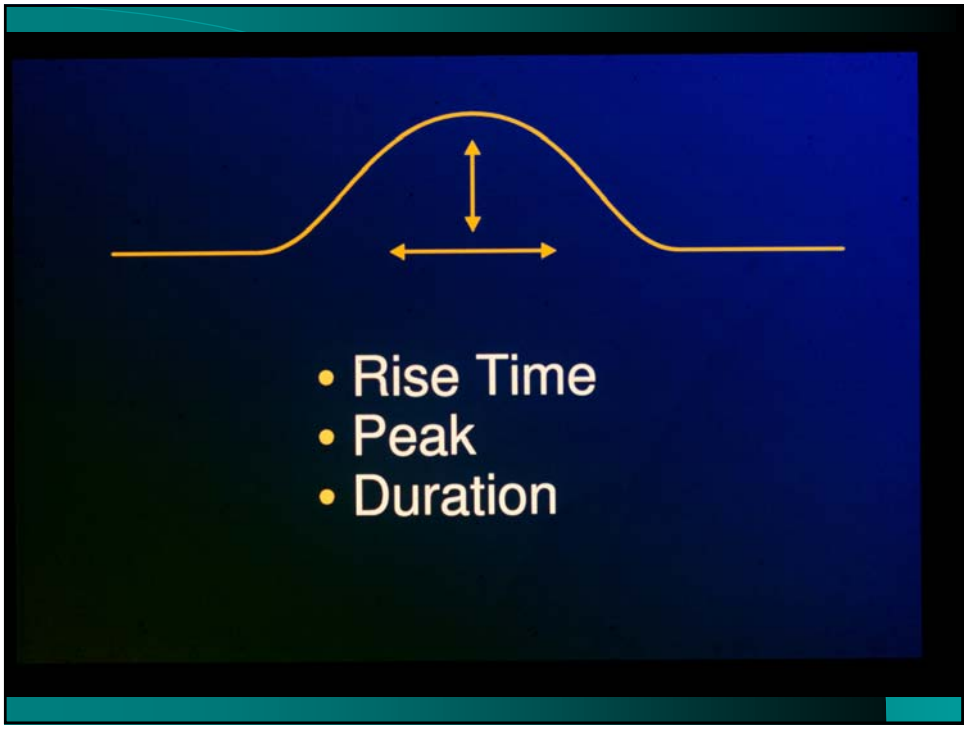
Why "inching" doesn't work

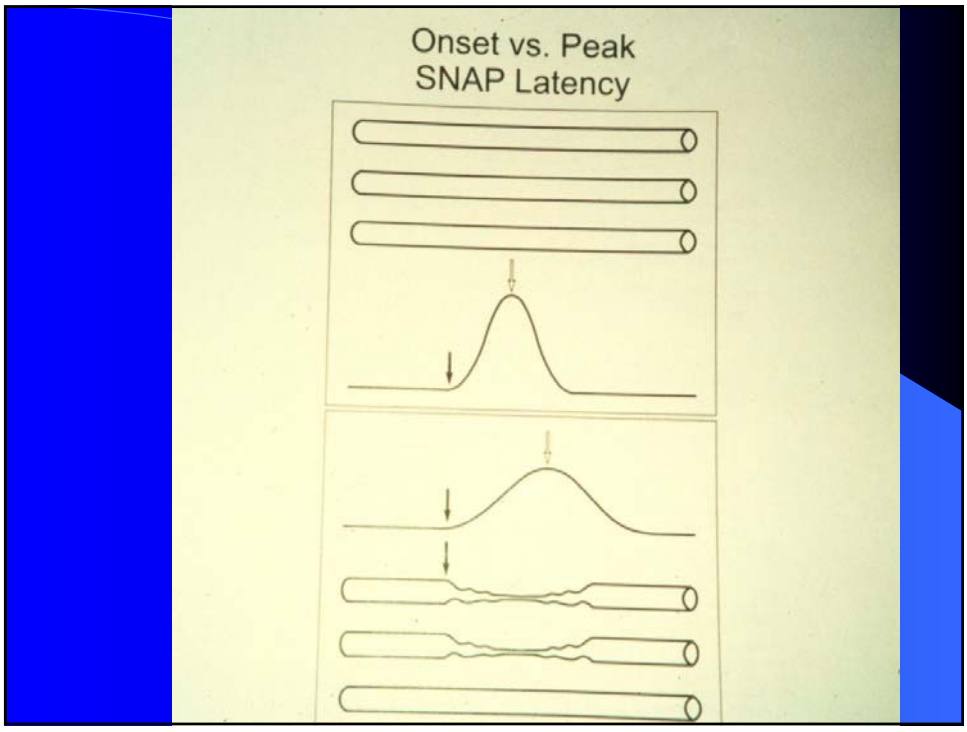
- Course of median nerve
  - Superficial at wrist
  - Deep in carpal tunnel
  - Superficial in palm



Why onset latency is NOT the best measurement

- If some of axons are normal –
  - Onset latency will be ***normal***
  - Rise time will be increased
  - Peak latency will be increased
  - Duration of negative spike will be increased


• Rise Time
• Peak
• Duration

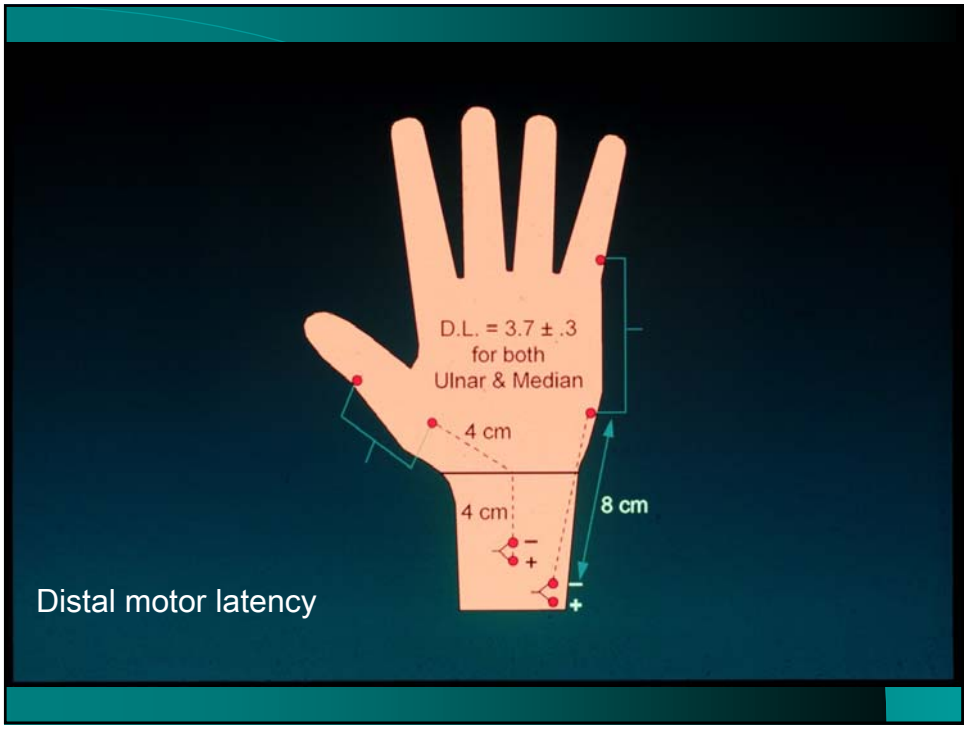

Onset vs. Peak
SNAP Latency

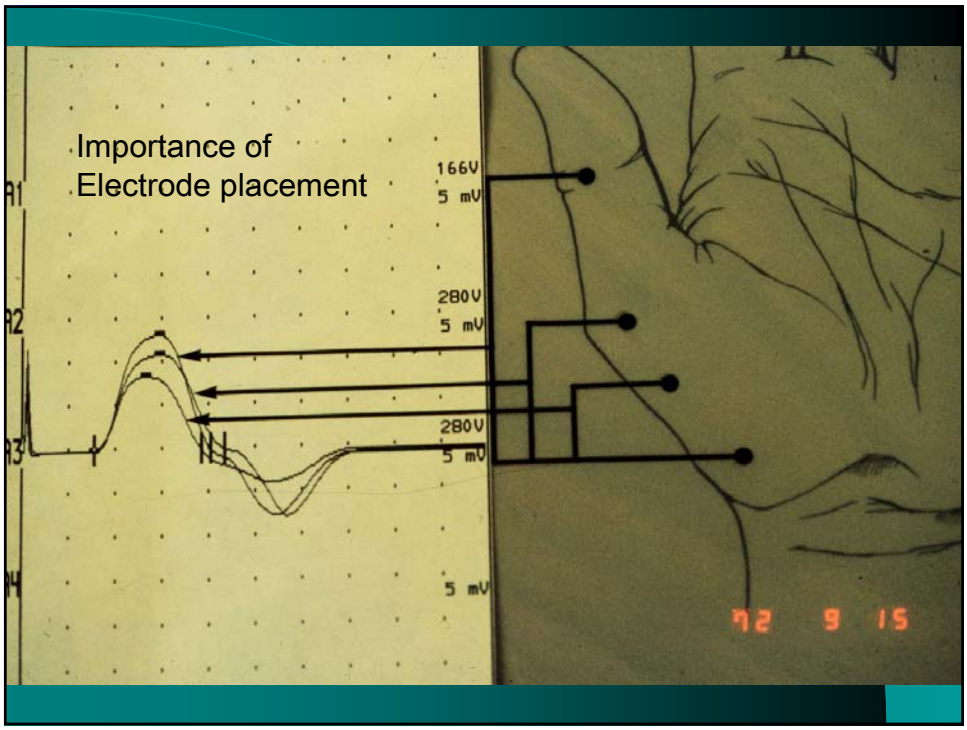
Reference values digit 3 7/14 cm

- Amplitudes – 7cm: 51 uV, 14 cm: 63 uV
- Latencies – 7 cm 1.6 ms; 14 cm 3.1 ms
- Durations - .9 (distal) – 1.2 ms (wrist)

Numbers to remember

- SNAP will increase <30% at 7 cm stim
- Duration of negative spike is most SENSITIVE for slowing in carpal tunnel
  - 1.1 ms at wrist stim (14 CM)
  - .9 ms at mid palm 7 cm)


D.L. = 3.7 ± .3
for both
Ulnar & Median
4 cm
4 cm
8 cm
Distal motor latency

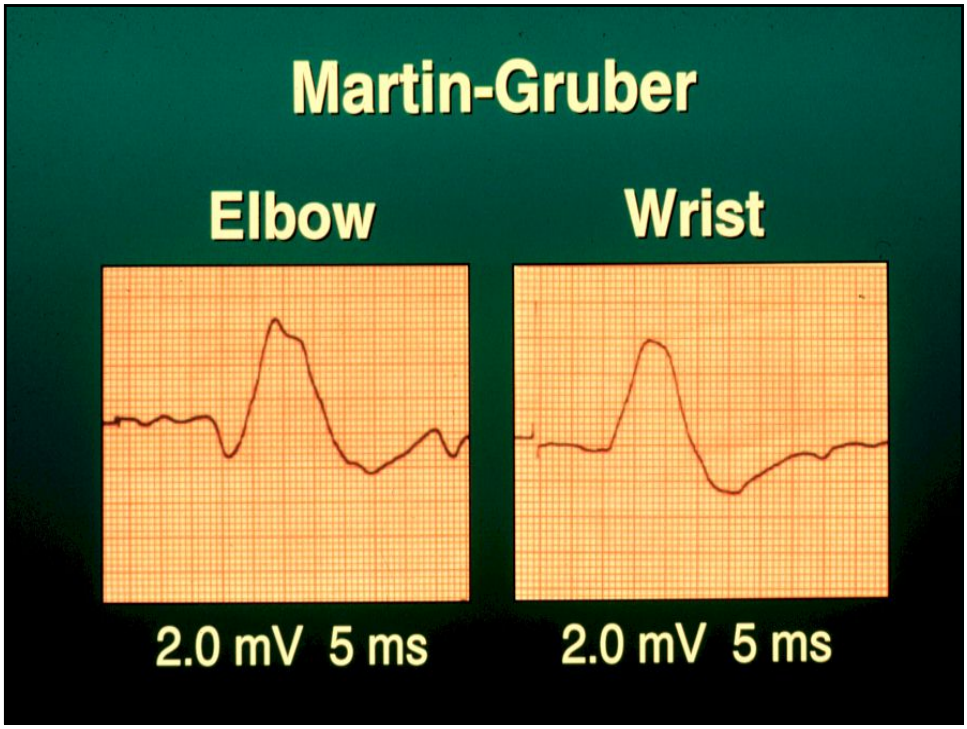

Importance of
Electrode placement
166V
5 mV
280V
5 mV
280V
5 mV
5 mV
92 9 15

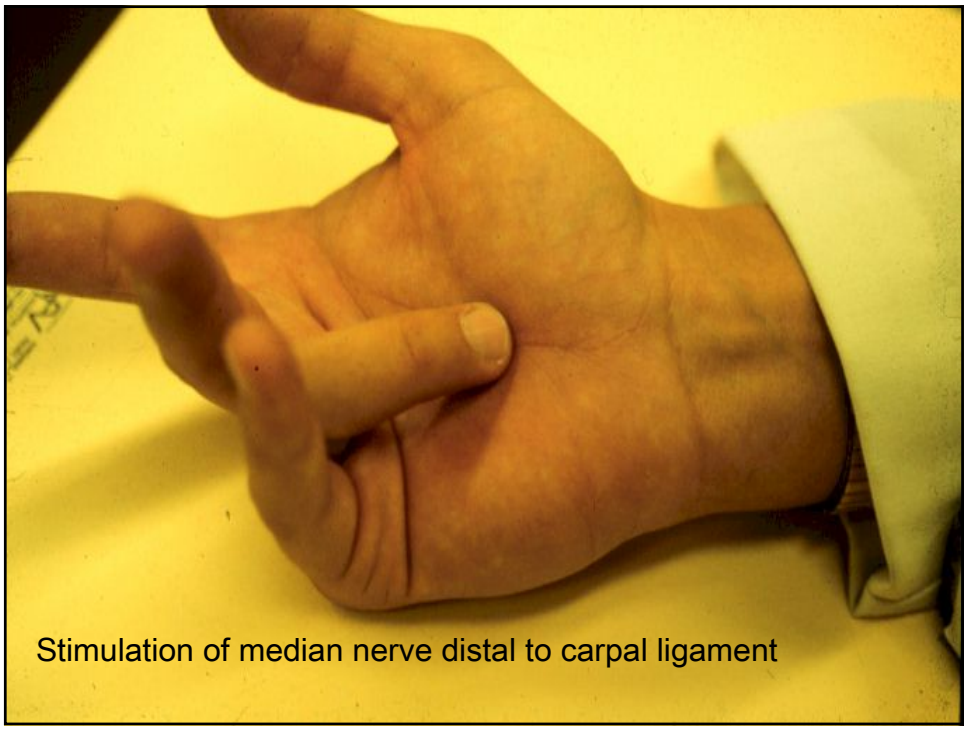
Difference in latency median and ulnar nerves

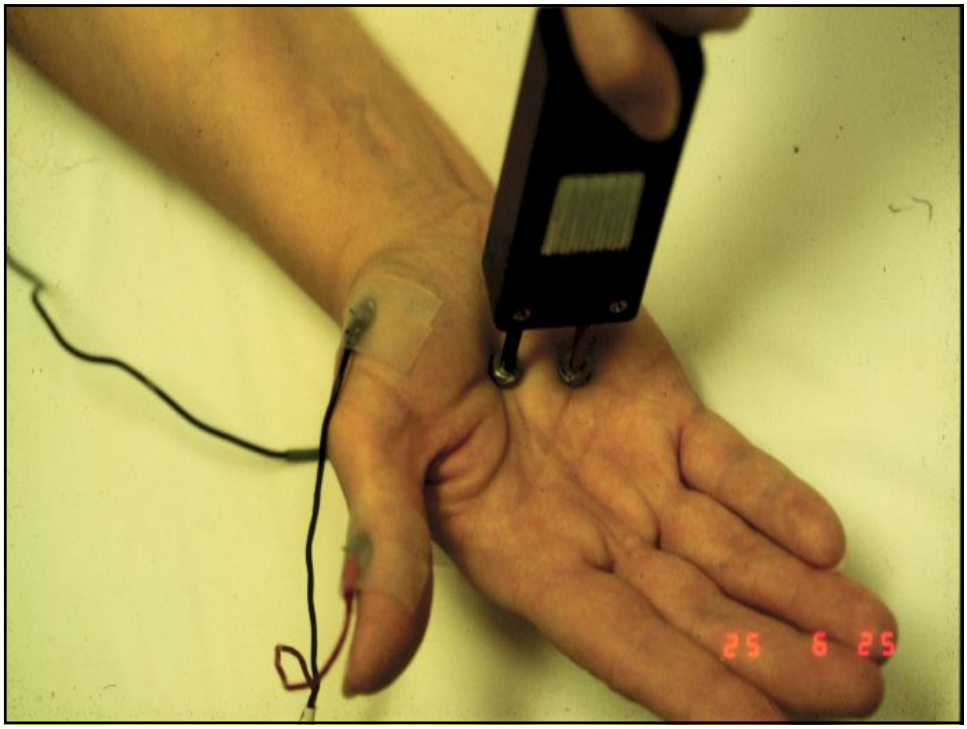
- If one measures carefully, the ulnar latency will be slightly shorter
- Median nerve travels longer as it curls back to thenar muscles
- DIFFERENCE =/< .5 ms

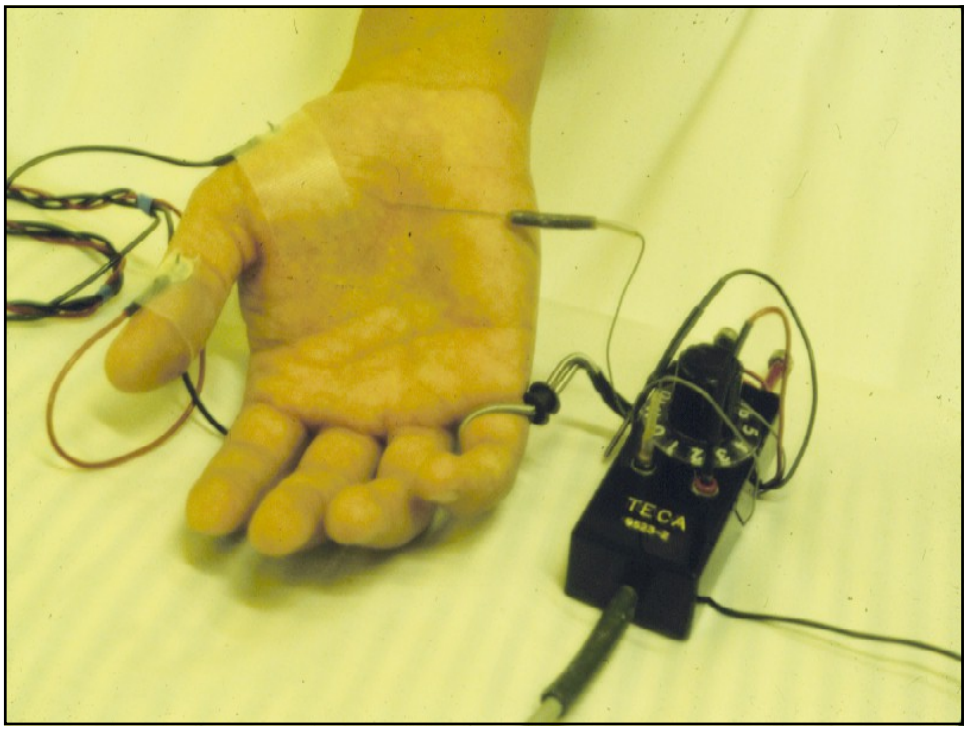
Martin-Gruber anomaly

- ***3 red flags*** of M-G anomaly in ***CTS***
  - CMAP has initial positive deflection at elbow stimulation
  - CMAP larger at elbow stimulation
  - CV is falsely fast (can even be negative)
  - NB. In ***normal*** only sign is larger CMAP at elbow stimulation


Martin-Gruber
Elbow
Wrist
2.0 mV 5 ms
2.0 mV 5 ms


Stimulation of median nerve distal to carpal ligament

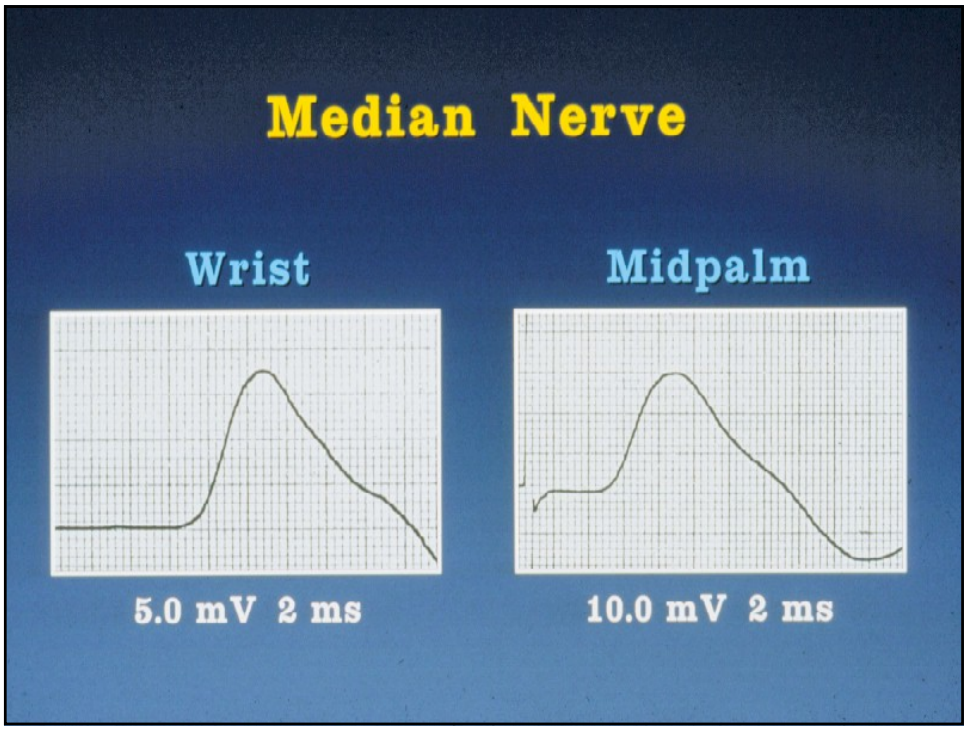

25 6 25

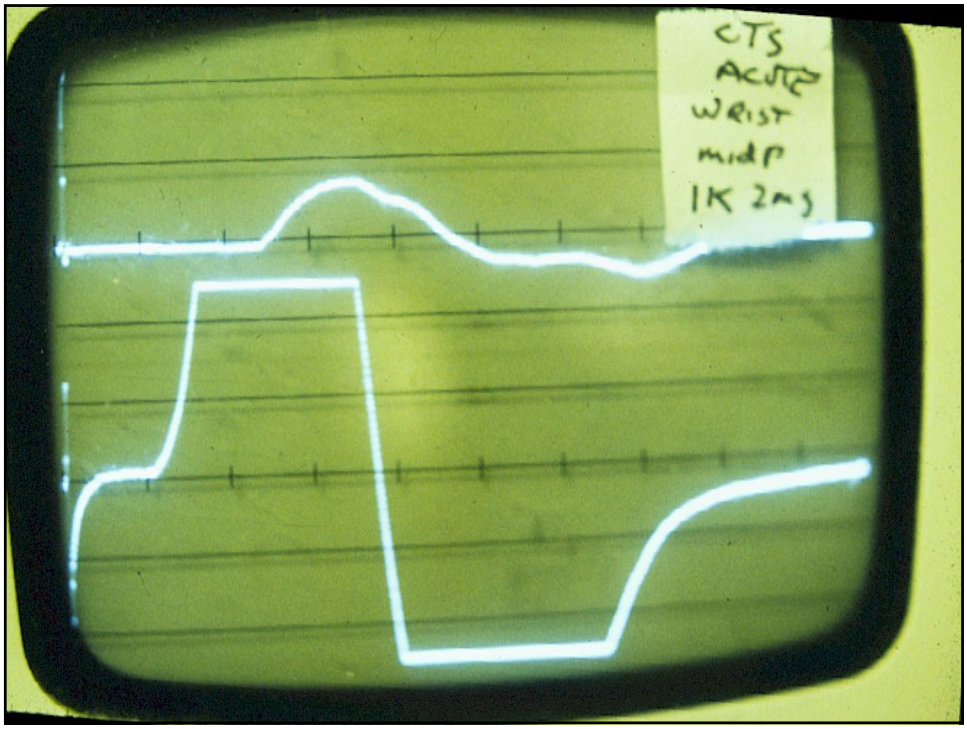

TECA

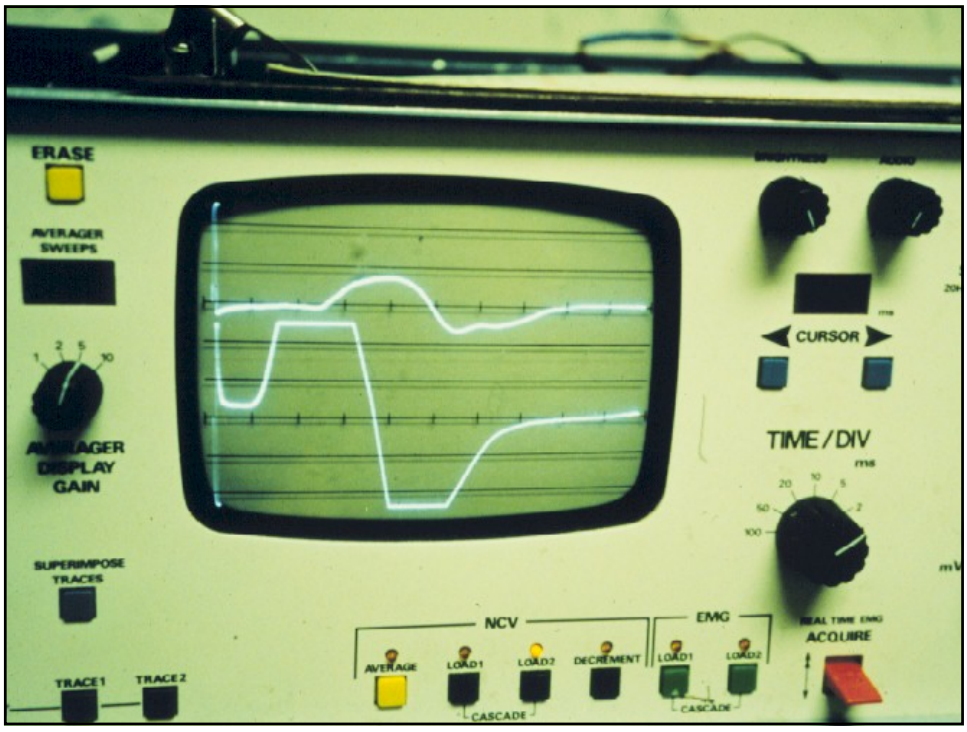
Wrist and midpalm stimulation

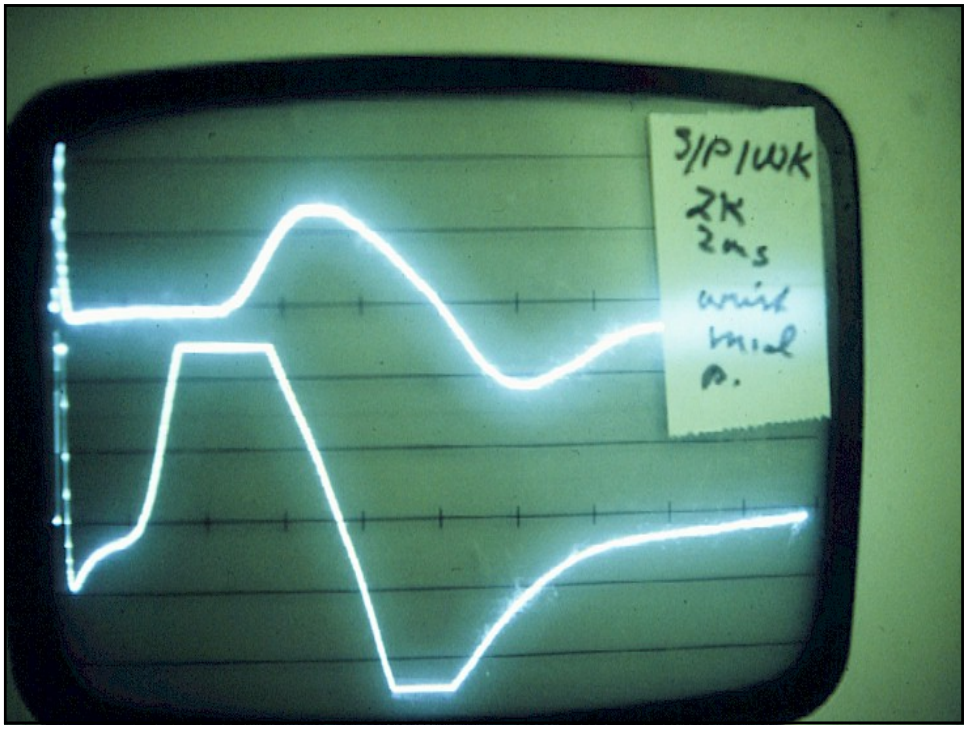
- Best way to show ***conduction block*** of motor axons
- Can be 'acute' CTS
  - Hx of vigorous use of wrist or hand eg.
    playing hockey for 6 days in a row
    Or using hand sprayer for 8 hours a day

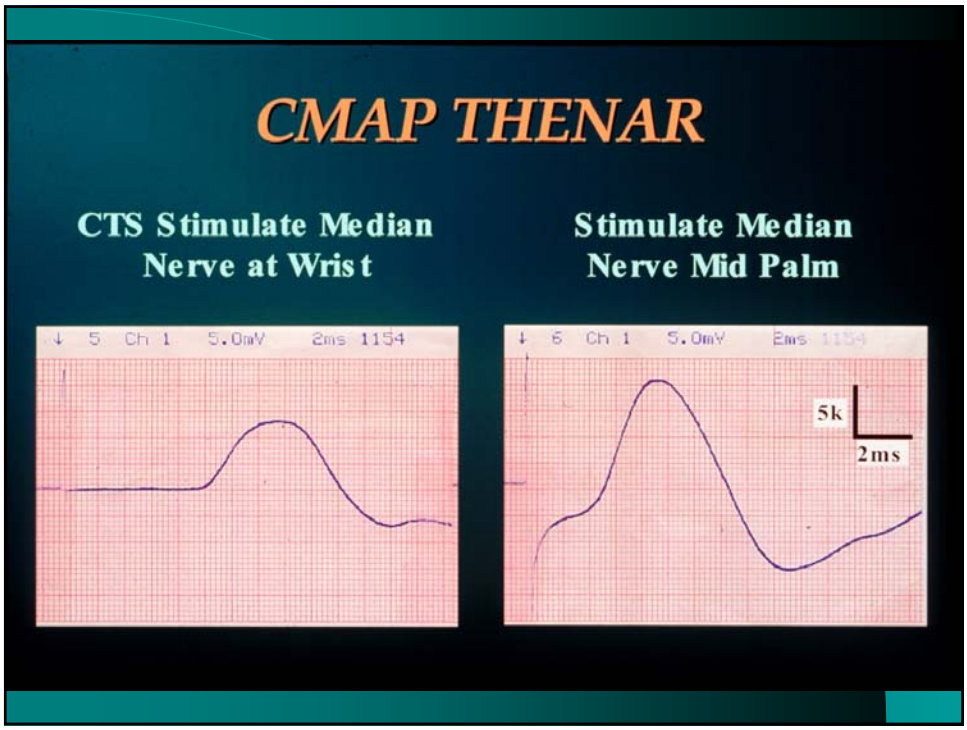
NB. Normal increase of CMAP <1 MV (10%)

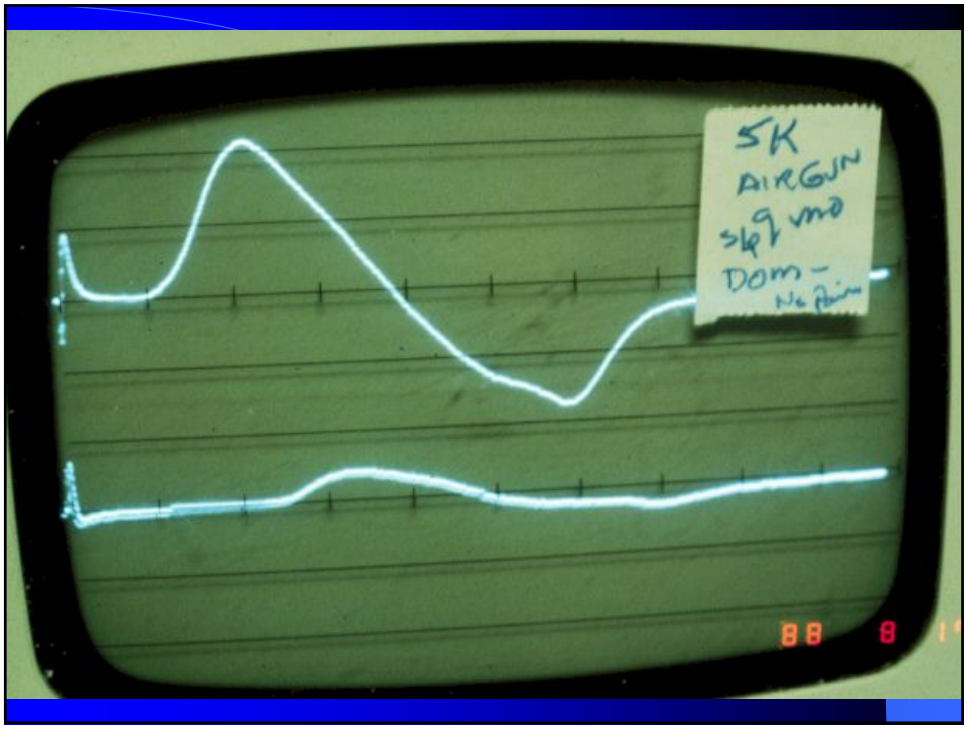



CTS
ACNE
WRIST
midP
1K 2mg


ERASE
AVERAGER SWEEPS
AVERAGER DISPLAY GAIN
SUPERIMPOSE TRACES
TRACE1
TRACE2
CURSOR
TIME / DIV
NCV
AVERAGE
LOAD1
LOAD2
DECREMENT
CASCADE
EMG
LOAD1
LOAD2
CASCADE
ACQUIRE

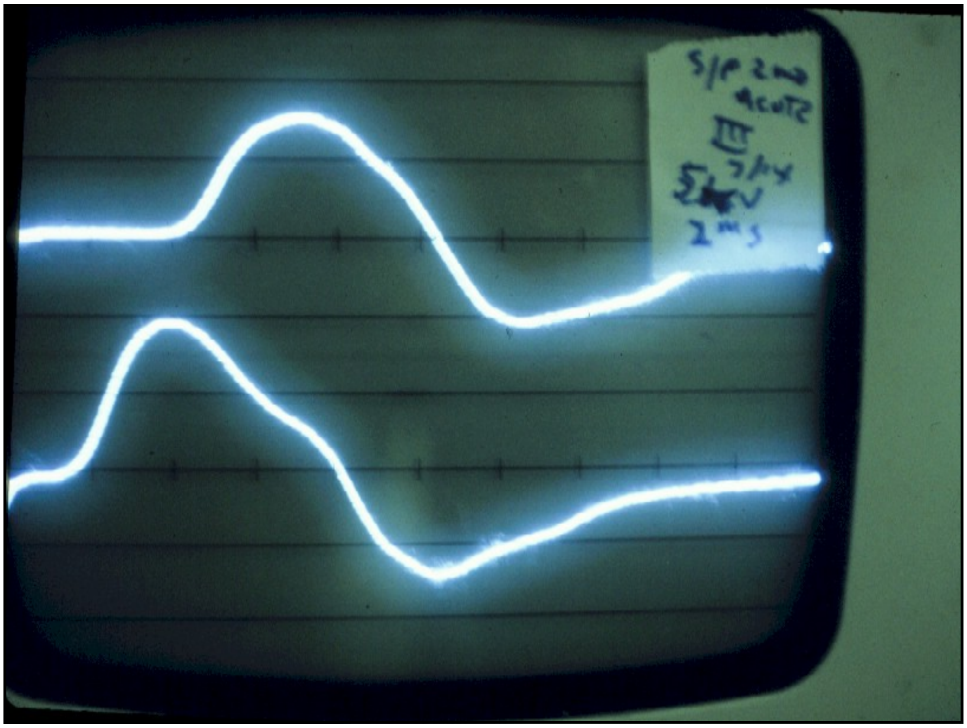

S/P 1WK
2K
2ms
wrist
mid
p.

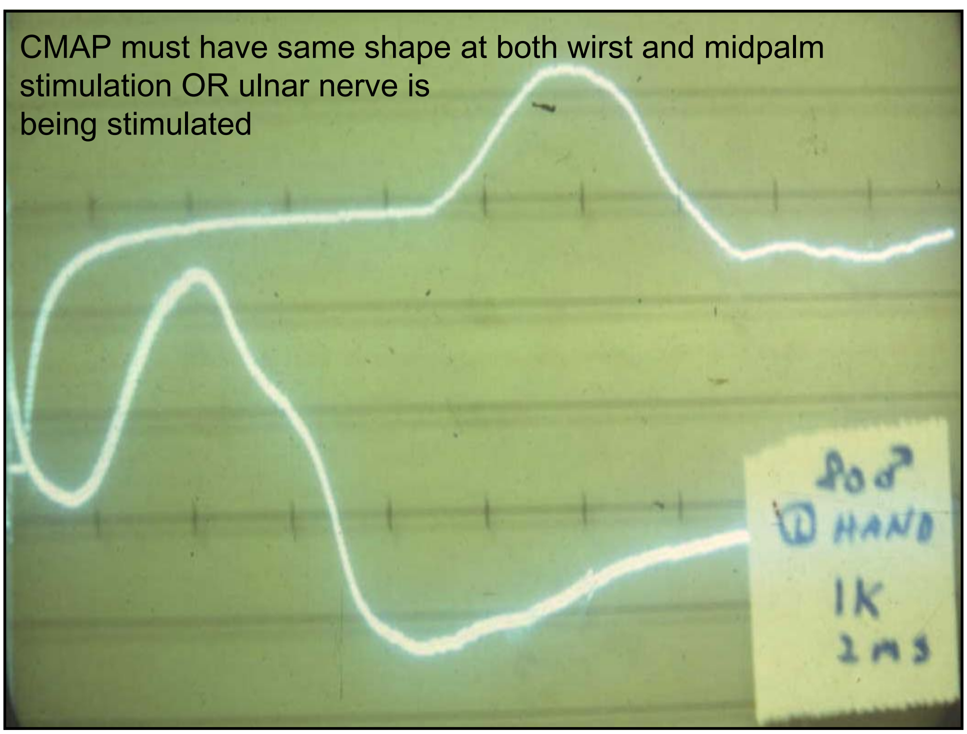

CMAP THENAR
CTS Stimulate Median Nerve at Wrist
Stimulate Median Nerve Mid Palm
↓ 5 Ch 1 5.0mV 2ms 1154
↓ 6 Ch 1 5.0mV 2ms 1154
5k
2ms



CMAP SHAPE MUST BE ***SAME***

FOR WRIST AND MID-PALM OR ***ULNAR NERVE*** IS STIMULATED


2ms

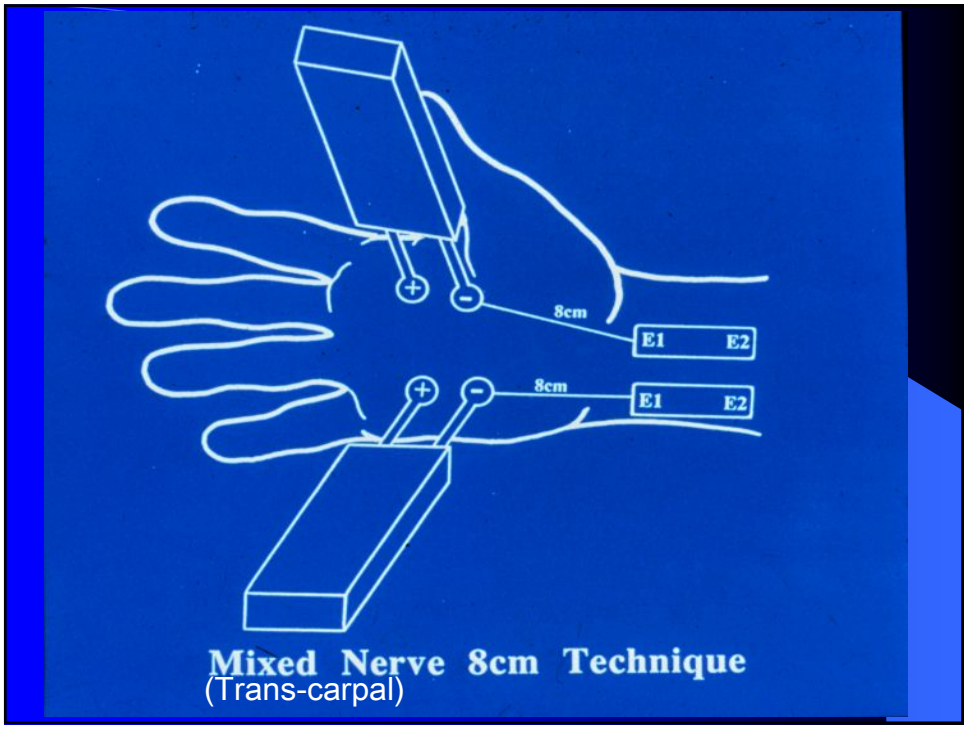

CMAP must have same shape at both wirst and midpalm stimulation OR ulnar nerve is being stimulated
HAND
1K
2ms

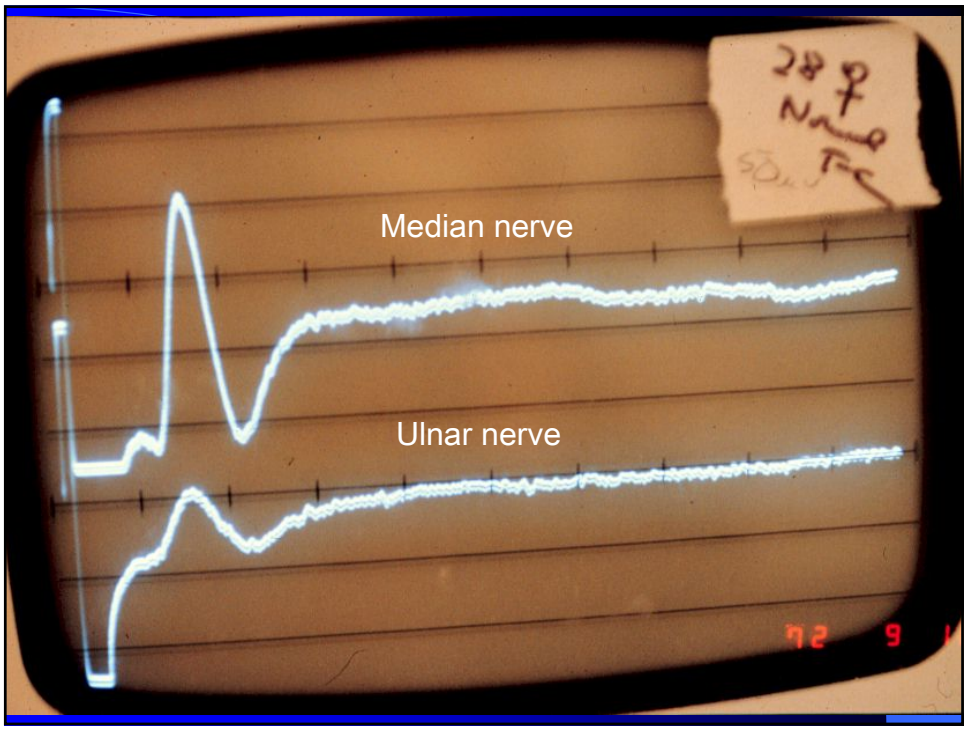
"Expected amplitude of Median CMAP if bilateral CTS is present

- Mid palmar strimulation will give approximate CMAP for "living" axons
- However, if patient has ***bilateral CTS***
  - ***Best estimate of expected normal will be within 1 millivolt of ulnar CMAP***

Numbers to remember

- CMAP will increase 10% or less at mid palm stimulation
- NB. Shape of CMAP must be same or ulnar nerve was stimulated
- If uncertain re: expected (normal) amplitude; CMAP of hypothenar will be w/in 1 millivolt


8cm
E1
E2
8cm
E1
E2
Mixed Nerve 8cm Technique
(Trans-carpal)

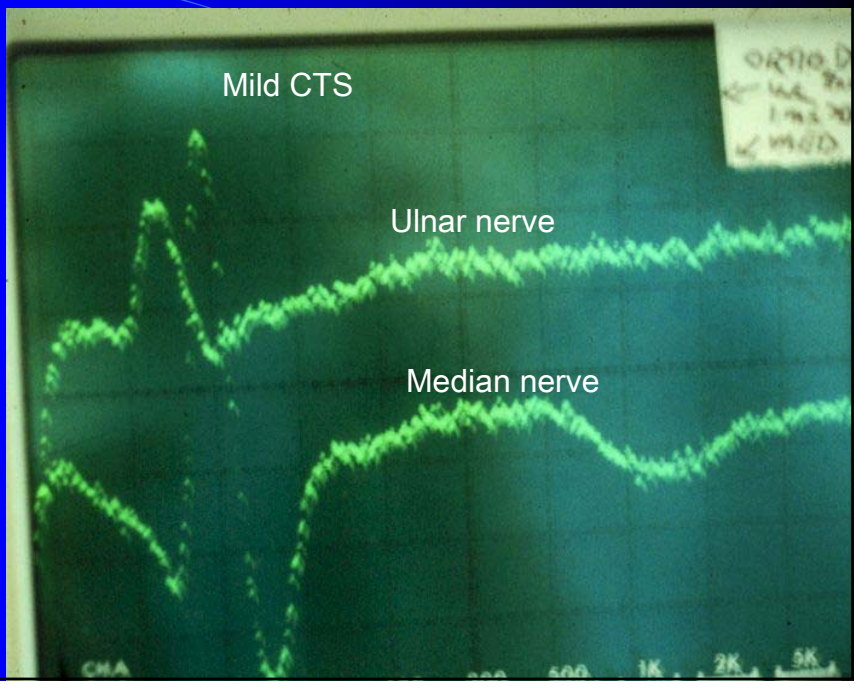

Median nerve
Ulnar nerve

Trans-carpal values

- Latency = 1.8 ms +/- .2
- Amplitudes – median 80 – 150 uV; ulnar – 20 - 40 uV

- NB. Latency difference =/< .3 ms(EWJ)

(Stevens - .2 ms; Wertz - .4 ms)

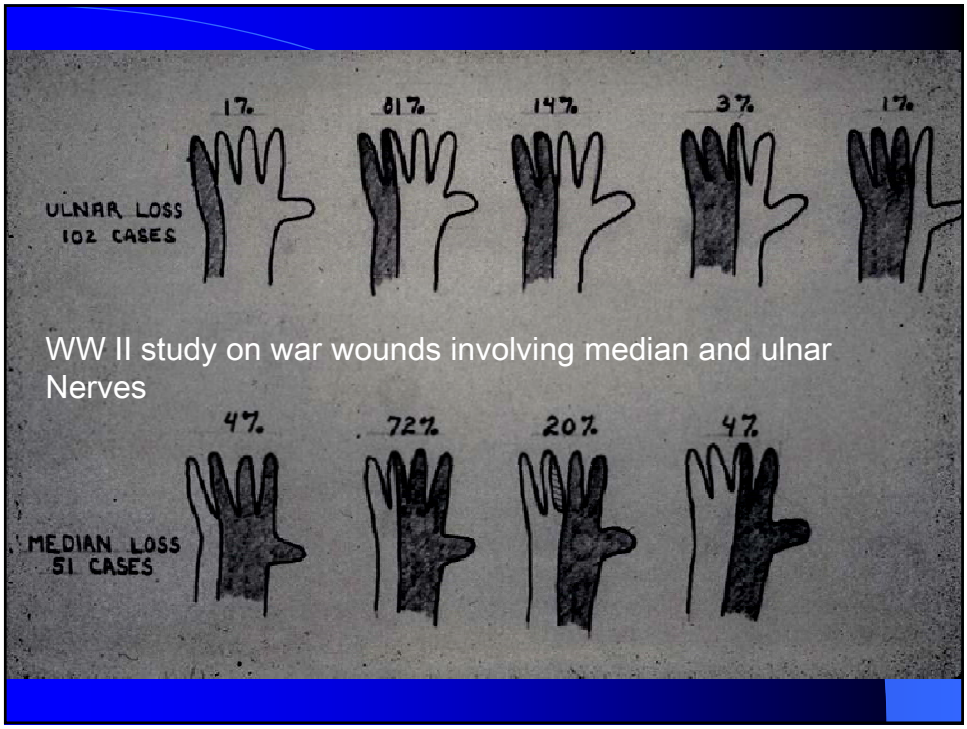


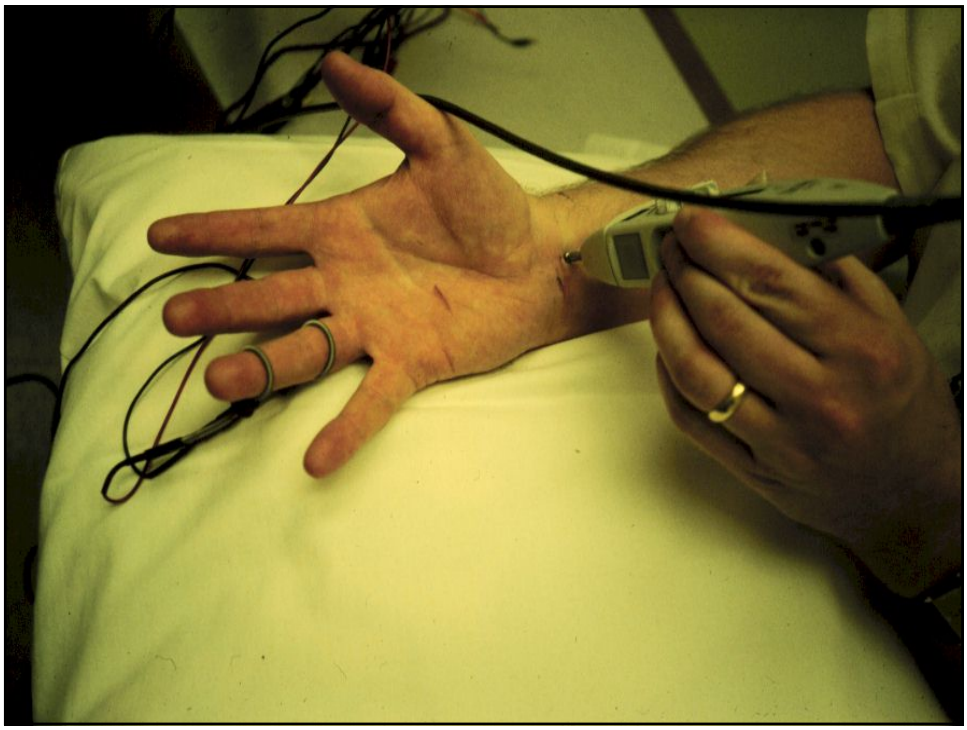
What's wrong with MIXED NERVE LATENCY?

- IT includes both motor (to lumbricals) and sensory nerve fibers
  - Unless motor and sensory are equally affected – values can be misleading
  - If motor is OK and sensory latency prolonged – can be missed diagnosis

Median/Ulnar SNAP Digit 4

- Useful in questionable cases
- Helpful in CTS with underlying neuropathy
- Some say "best single test" for CTS
- ***NB. "we prefer median /radial to thumb"***


1%
81%
14%
3%
1%
ULNAR LOSS
102 CASES
WW II study on war wounds involving median and ulnar Nerves
4%
72%
20%
4%
MEDIAN LOSS
51 CASES



Original study – ulnar & median to digit 4

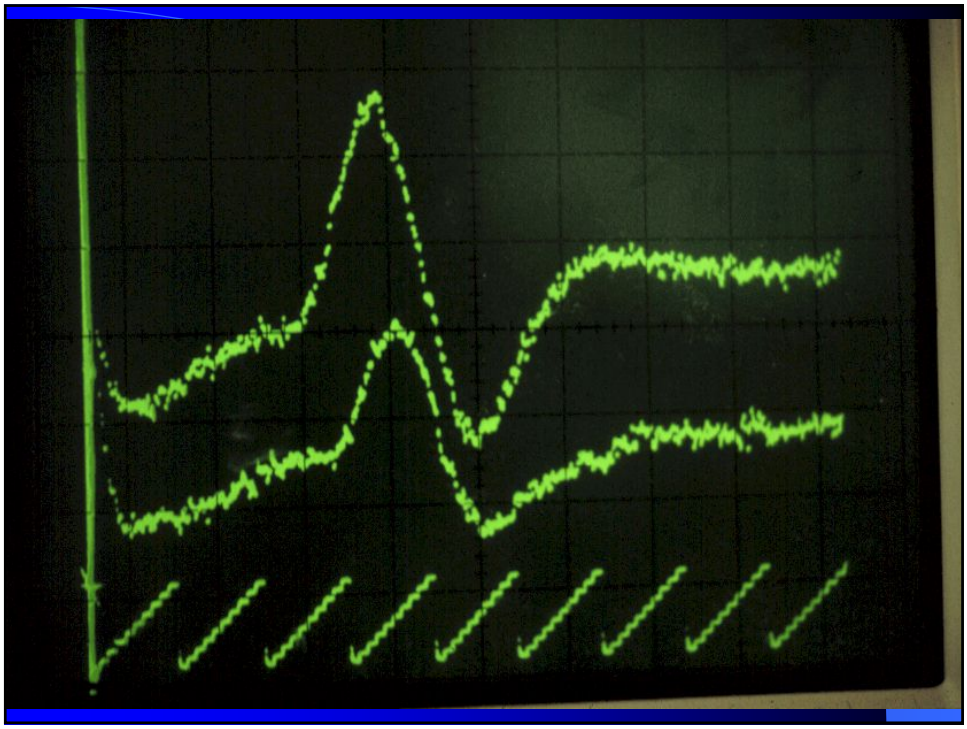
Johnson, Kukla, Wongsam, Piedmont

Arch Phys Med & Rehab 1981

MEAN LATENCY ± SD
(MEAN + 2SD)

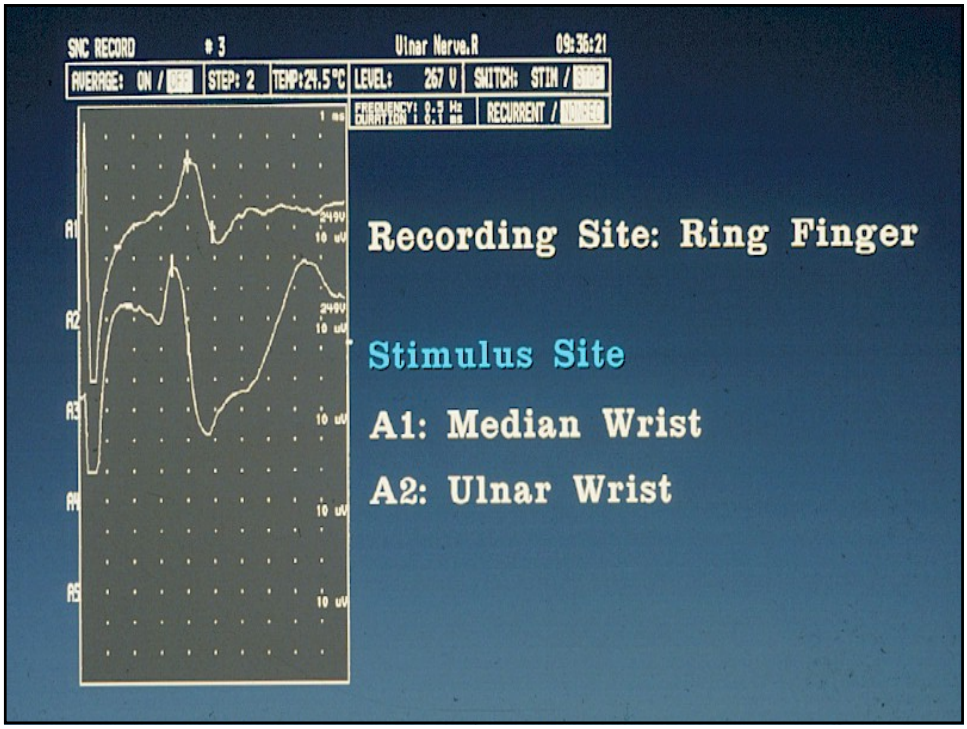
	# SUBJ	AGE RANGE	SEX F	SEX M	DOM. HAND MED IV	DOM. HAND UL IV	NON-DOM. HAND MED IV	NON-DOM. HAND UL IV
	10	20-29	5	5	3.12±.18 (3.5)	3.11±.15 (3.4)	3.15±.18 (3.5)	3.06±.16 (3.4)
	10	30-39	4	6	2.96±.15 (3.3)	2.89±.20 (3.3)	2.96±.22 (3.4)	2.91±.20 (3.3)
	7	40-49	4	3	3.19±.27 (3.7)	3.04±.20 (3.4)	3.19±.30 (3.8)	3.19±.29 (3.8)
	10	50-59	5	5	3.30±.23 (3.8)	3.08±.23 (3.5)	3.28±.24 (3.8)	3.12±.24 (3.6)
Total	37		18	19	3.14±.24 (3.6)	3.03±.21 (3.5)	3.11±.32 (3.7)	3.01±.32 (3.6)

FINAL STUDY



Digit 4 SNAP (14 cm)

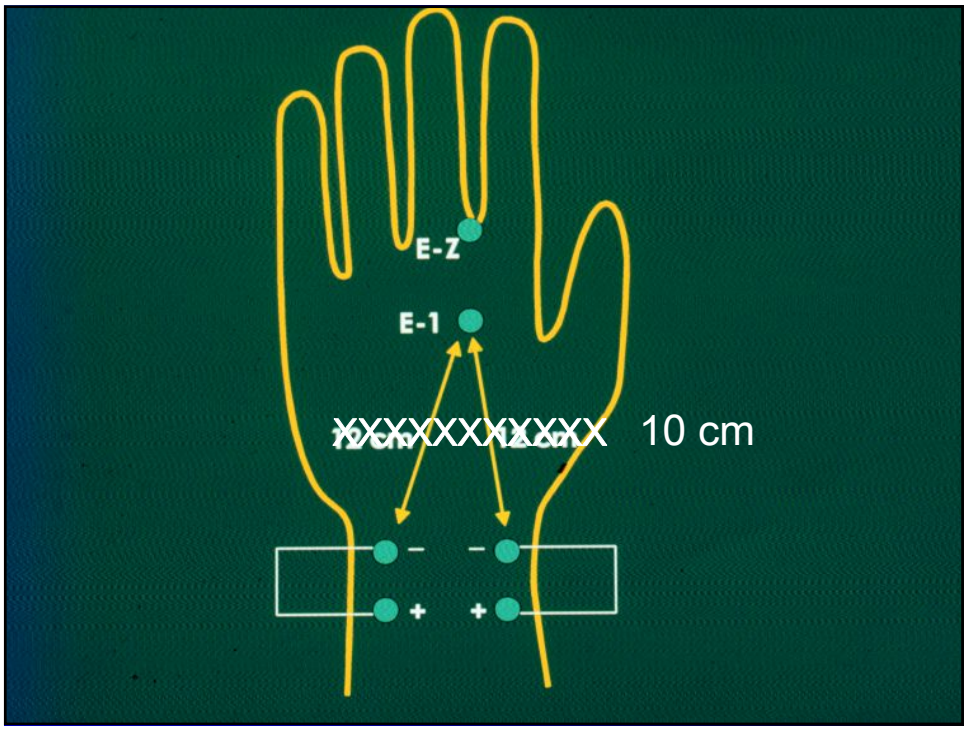
- Amplitude – 30 uV w/median>ulnar
- Latency – 3.0 ms +/- .2 ms
- 95% difference =/< .3 ms

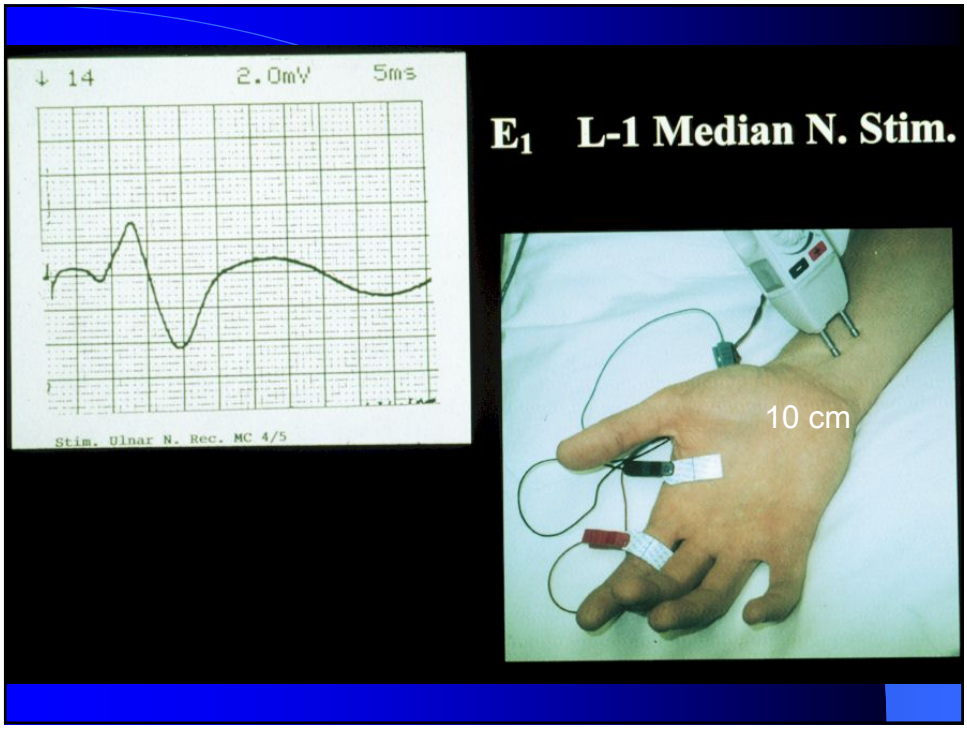

SNC RECORD
3
Ulnar Nerve.R
09:36:21
AVERAGE: ON / OFF
STEP: 2
TEMP:24.5°C
LEVEL: 267 V
SWITCH: STIM / OFF
FREQUENCY: 0.5 Hz
DURATION: 0.1 ms
RECURRENT / NUMBER
A1
A2
A3
A4
A5
10 uV
Recording Site: Ring Finger
Stimulus Site
A1: Median Wrist
A2: Ulnar Wrist

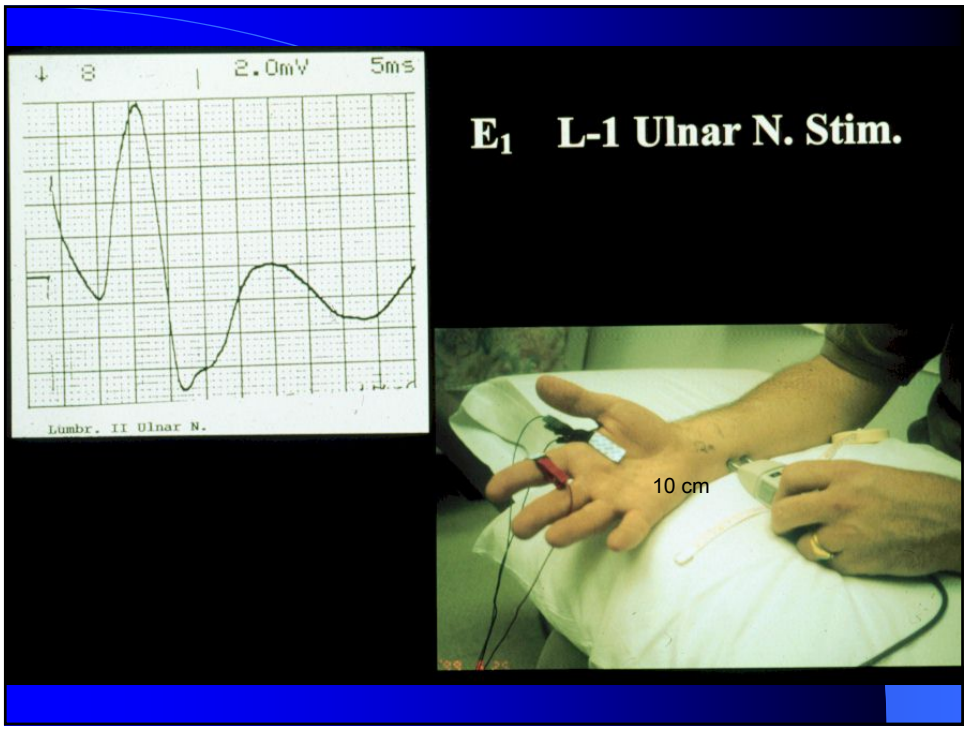

MOTOR
MEDIAN/ULNAR
TO INTRINSICS
A

Median/Ulnar CMAP to intrinsic muscles

- 12 cm from Lumbrical I or II
- Stimulate median nerve
  - CMAP will be 1-2 millivolts
- Stimulate ulnar nerve
  - CMAP will be 4-6 millivolts
    - Latency difference =/> .5 ms

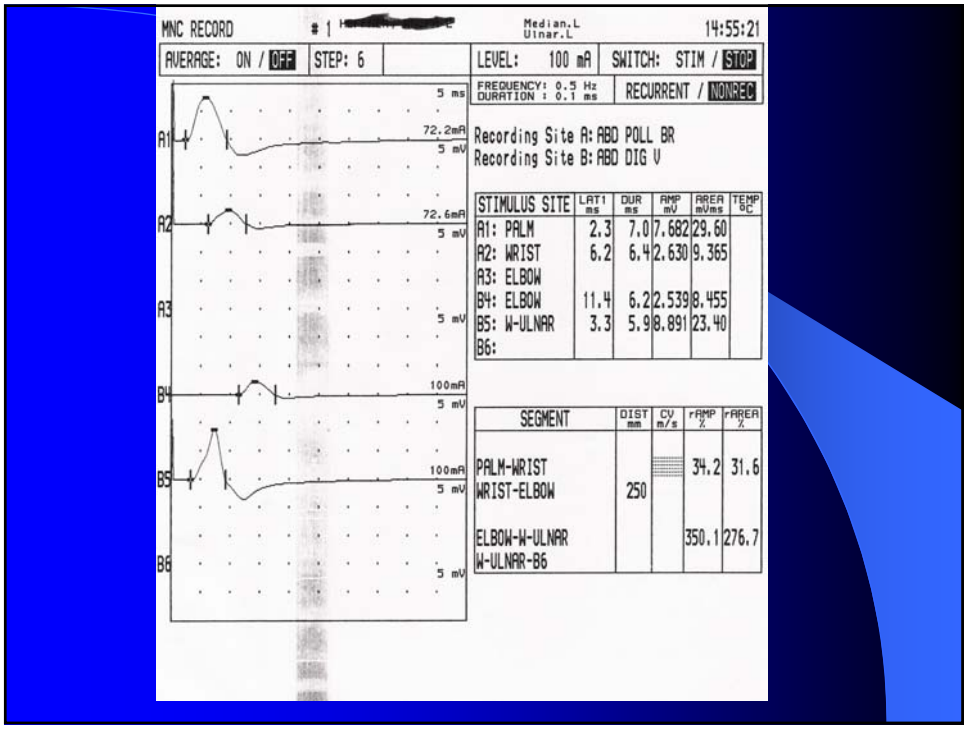


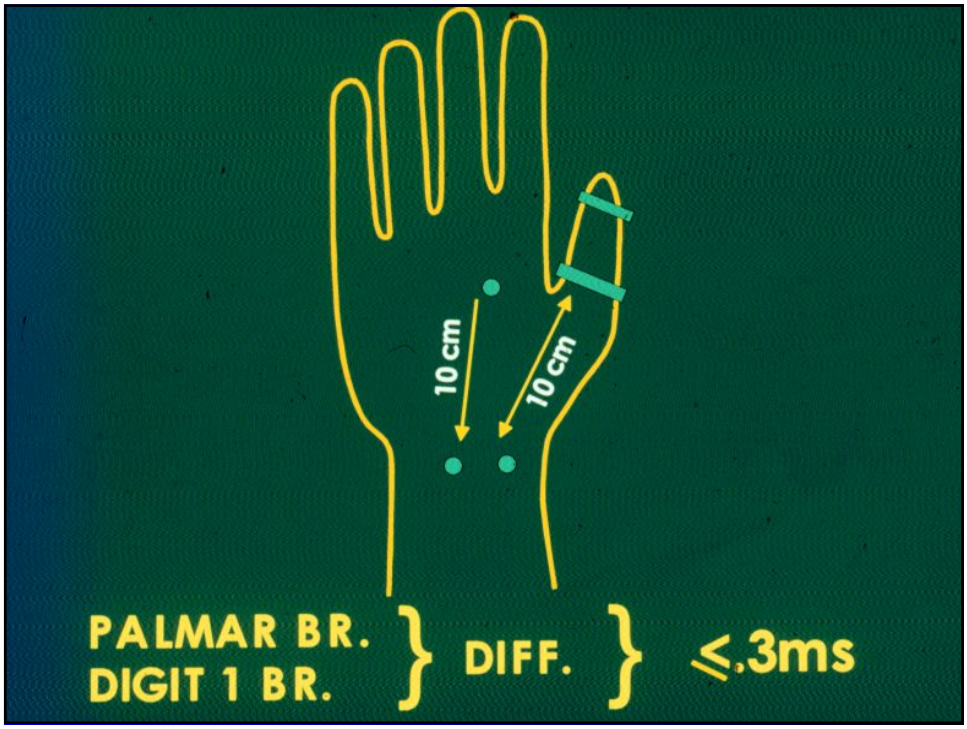

↓ 14
2.0mV
5ms
Stim. Ulnar N. Rec. MC 4/5
E1 L-1 Median N. Stim.
10 cm


↓ 8
2.0mV
5ms
Lumbr. II Ulnar N.
E1 L-1 Ulnar N. Stim.
10 cm

LUMBR. I or II
12 cm

ULNAR } LATENCY } ≤ .5ms
MED } DIFF. }





Another technique if there is question

- Lumbrical I or II recording
- Stimulate median nerve
- Increase GAIN to 50 uV/cm
- SNAP recorded is from palmar branch of median nerve (escapes carpal tunnel)
- Compare with median SNAP digit I (same distance)

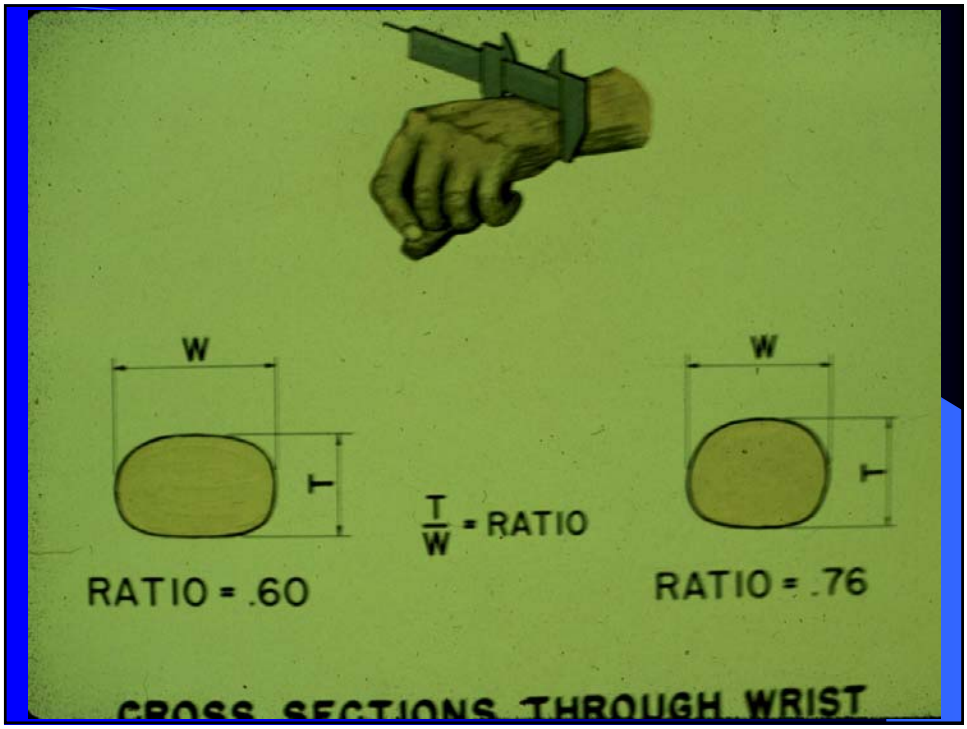
LATENCY IS NOT THE BEST MEASURE

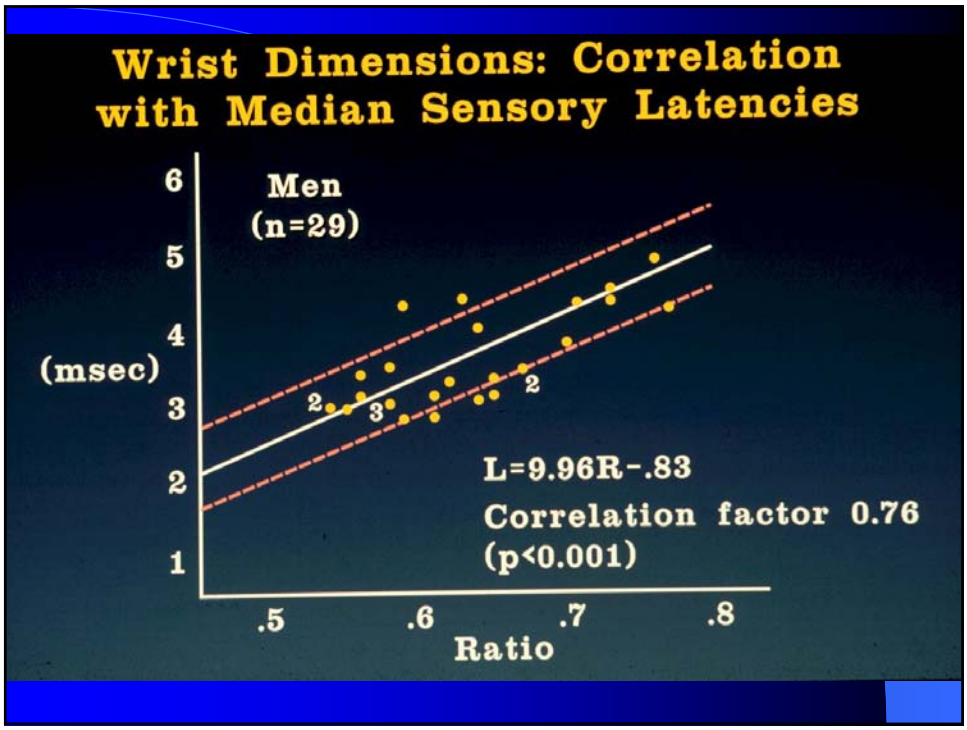
- Latency ONLY reflects the demyelination in the carpal tunnel
- Latency is NOT measure of dead axons

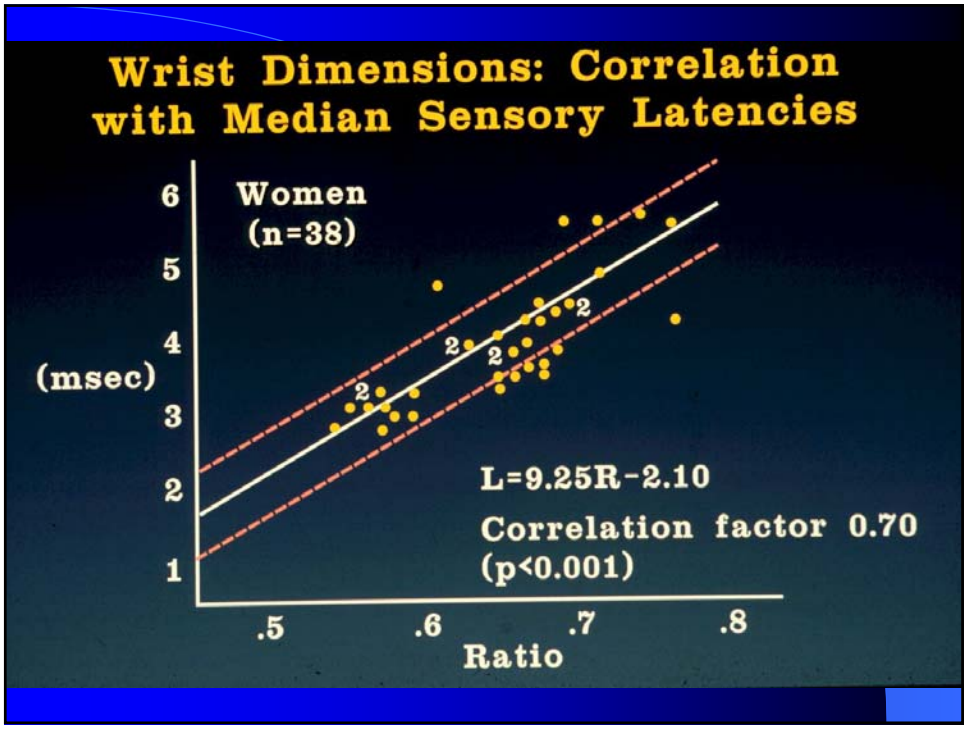
Wrist dimensions – correlation with median N latencies

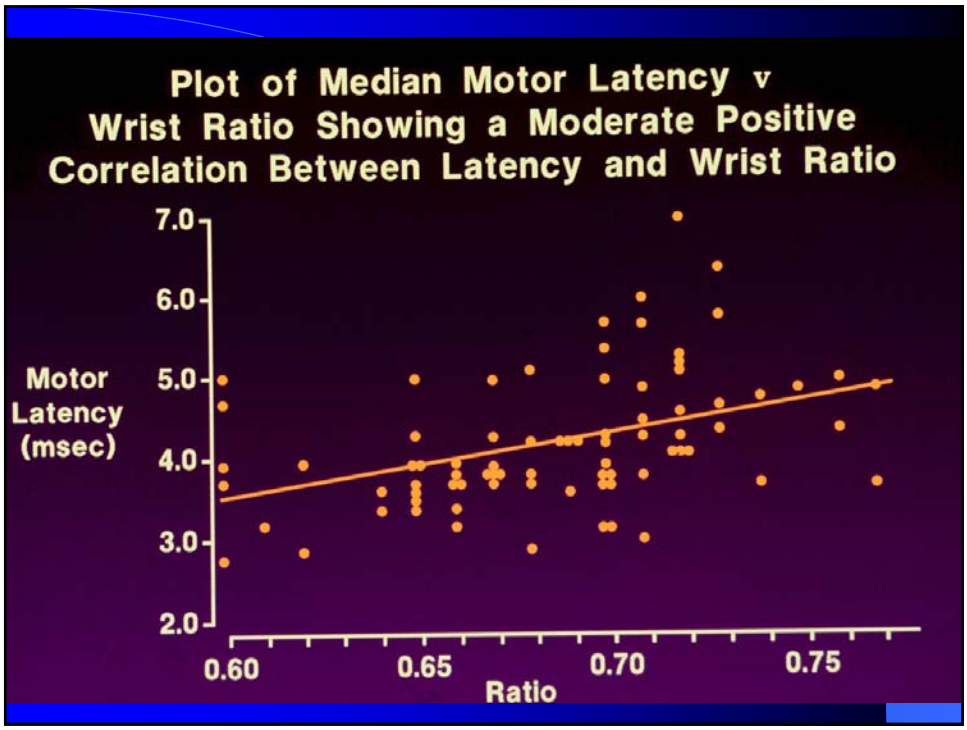
Johnson, Gatens, Poindexter, Bowers

Arch Phys Med & Rehab 1983


W
T
W
T
T/W = RATIO
RATIO = .60
RATIO = .76
CROSS SECTIONS THROUGH WRIST


Wrist Dimensions: Correlation with Median Sensory Latencies
Men
(n=29)
(msec)
6
5
4
3
2
1
2
3
2
L=9.96R-.83
Correlation factor 0.76
(p<0.001)
.5
.6
.7
.8
Ratio


Wrist Dimensions: Correlation with Median Sensory Latencies
Women
(n=38)
(msec)
6
5
4
3
2
1
L=9.25R-2.10
Correlation factor 0.70
(p<0.001)
.5
.6
.7
.8
Ratio


Plot of Median Motor Latency v Wrist Ratio Showing a Moderate Positive Correlation Between Latency and Wrist Ratio
Motor Latency (msec)
7.0
6.0
5.0
4.0
3.0
2.0
0.60
0.65
0.70
0.75
Ratio

BEST TESTS

- Most sensitive and specific ***screen***
  - I used to say (good studies support)– digit I median/radial SNAP
  - Some say – digit 4 median/ulnar SNAP
  - Robinson – 3 techniques 2/3 will be best
  - ***NOW – I say digit 1 for screen; then one must stimulate proximal and distal to carpal lig. ie. 7/14 cm digit 3; CMAP proximal & distal to carpal lig***

BEST EDX for CTS (*ala Johnson*)

- Screen "numb thumb"
- Median SNAP digit 3 at 7 and 14 cm
- CMAP thenar, proximal and distal to CT
- If need more data of nerve function- sensory - Ulnar SNAP to digit 5 (or compare median and ulnar to digit 4)
- Motor – median/ulnar to interossei

If I'm still doubtful

- Review the Hx and Px
- What am I thinking?
  - Generalized?
  - Co-incident condition?
- Rarely in simple CTS – Needle EMG!

Bottom line

- ABNORMAL – for diagnosis
  - Sensory diff =/> .3ms
  - Motor diff =/. .5 ms
  - NB. THESE ARE "RED FLAGS" for diagnosis

FOR SEVERITY - amplitudes on both sides of carpal ligament !

Severity = amplitude

- Latency IS IRRELEVANT TO severity
- Severity is determined by amplitude of SNAP & CMAP ***distal*** to the carpal tunnel

DON'T FORGET

- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude
- Amplitude

IF ANY RED FLAGS -

- Needle EMG
- Sural nerve SNAP
- Ulnar nerve F wave
- Try other techniques
  - T-C mixed CNAP
  - Dig 4 –Ulnar/median SNAP
  - Lumbar/interossei CMAP

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- Stevens,J:AAEE Minimonograph #26. 1987. Muscle & Nerve10:99

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Super EMG Kauai

11 Feb – 18 Feb, 2006