Ultrasound Imaging of the Median Nerve
Carpal Tunnel Syndrome

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Why Ultrasound and EDX?

1. Collaborative/Supplemental – provides anatomic info about the nerve;
correlate with EDX and clinical exam
2. Provides dynamic physiologic information about the nerve during motion
3. Provides functional info about surrounding structures (mm, tendon, etc),
and how they interact with the nerve during activity
4. Do the Ultrasound findings correlate (degree and location of swelling)?
5. EDX is still the ‘gold standard’; perform EDX first to plan US imaging
6. Use the Ultrasound findings to optimize management decisions
**The Thumb**

‘The human thumb emerges as a compromise at one point in evolutionary time, a locomotor organ that has been transformed into a manipulative organ (by stone tool use).

Frank Wilson, The Hand, 1998

‘...the modern human brain came into being after the hominid hand became “handier” with tools, ...the human brain was the last organ to evolve”.

“...both the most delicate and the most dangerous of the primates”.

“Because of its unique capabilities...the thumb, if need be, can carry on as a solo act”.

Frank Wilson, The Hand, 1998
The Thumb
Just how important and powerful is it?

ETIOLOGY OF CTS
- IDIOPATHIC - is it really?
- INFLAMMATORY: Tendonitis/Rheumatoid
- ARTHRITIC: DJD/OA
- CARPAL CANAL STENOSIS / FIBROSIS
- WORK-RELATED: Trauma, Repetition, Awkward Posturing, Vibration, Cold
- MISCELLANEOUS: Connective Tissue, Endocrine, Amyloid, etc.

DIAGNOSTIC EVALUATION OF CTS
- HISTORY
- PHYSICAL EXAM
- EDX-ELECTRODIAGNOSIS (EMG/NCS)
- X-RAY-Carpal Canal Views
- ULTRASOUND (high resolution, 12+ MHz)
- MRI

“Electrodiagnostic studies remain the gold standard for verification and diagnosis of a median neuropathy”
ULTRASOUND EVALUATION OF CTS

1. a. CSA at pisiform
1. b. CSA Forearm (if 9-11mm)

2. Digit flexion – lumbrical intrusion

3. Digit + wrist extension – sublimus intrusion

4. Longitudinal MN diameter pre-stress

5. Longitudinal MN diameter stress

6. Transverse MN diameter (optional)
   - 'Open-Mouth' view

7. Video MN stress (optional)
   a. longitudinal
   b. transverse

DIAGNOSTIC ULTRASOUND OF CTS

Normal
m = median nerve
t = flexor tendons
Max normal cross-sectional area <12mm²

Abnormal

Lee, Radiol Clin NA, 7/93
Steiger, JNP, Jan 2003
- Accuracy similar to EDX
Walker, AANEM, 9/08
- US and EDX complementary
**DIAGNOSTIC ULTRASOUND OF CTS**

**Normal**
- \( m \) = median nerve
- \( t \) = flexor tendons
- Max normal cross-sectional area <12mm²

**Abnormal**
- Enlarged + loss of fascicular echotexture = nerve edema
- Max normal cross-sectional area <12mm²
- Median DML = 7.3ms
- Distal (palmar) Amp = 0.6mV, prox = 1.7mV
- 80% conduction block
- Median DSL = 6.6ms to D1
- Amplitude = 2mcV

US and EDX complementary

**DIAGNOSTIC ULTRASOUND OF CTS**

Bifid Median Nerve (high division)

**DIAGNOSTIC ULTRASOUND OF CTS**

Normal
- Longitudinal View
- Axial View ('open-mouth')

Thenar muscles

TCL

Median nerve
**CTS Case #1**

70 y/o female with right UE pain, numbness, tingling, and weakness, for the past 2mos. Symptoms worse at night and with gripping activity.

**PE:** palpatory restriction over carpal canal, intact sensation
positive Tinel and Phalen tests

**EDX:**
Median DML 4.8ms (7mV) [Ulnar 2.7 (10mV)]
Median DSL D-1 3.9ms (11mcv) [Radial 2.7 (10mcv)]

**DIAGNOSTIC ULTRASOUND Case #1**

Lumbrical muscle intrusion

More frequent muscle intrusion in CTS [46-100%]

Larger volume of muscle intrusion in CTS [8mm vs. 4mm]

Cartwright, Holtzhausen

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**CTS Case #2**

44 y/o female with UE pain, numbness, tingling, and weakness, R>L, for the past 2 years; employed as a spa tech with wrists extended as performing pedicures.

**PE:** normal, except palpatory restriction over carpal canal

**EDX:**
Median DML 4.5ms [Ulnar 2.7]
Median DSL D-1 4.2ms [Radial 2.5]
42 y/o male with UE pain, numbness, and tingling, R>L, for the past 2 years. Treatment with wrist braces provided some relief. Works as computer programmer.

**PE:** normal, except for Tinel & Phalen tests positive bilaterally

**EDX:**
- Median DML: 2.8ms R; 2.9ms L (Ulnar 2.5 R+L)
- Median DSL D-1: 2.8ms R; 2.7ms L (Radial 2.4 R+L) (4.4/3)
- Median DSL D-4: 3.2ms R+L (Ulnar 3.0 R+L) (2.2/2)
- Median mixed: 1.8ms R; 1.9ms L (Ulnar 1.8 R; 1.9 L)

**CSI:** .6ms R; .5ms L
**DIAGNOSTIC ULTRASOUND OF CTS**

- 'Notching' of the median nerve on longitudinal/sagittal view.
- Transverse carpal ligament: maximal site of compression at distal tunnel.

Lee, Radiol Clin NA, 7:99

Beekman and Visser, Muscle & Nerve, Jan 2003, "Only in severe cases"

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**Median nerve Stress testing - Normal**

- Thum Digital Flexion Stress Test
- Pre-Stress (neutral): no median nerve narrowing.
- Stress: actual increase in diameter 30%.

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**Median Nerve Stress Testing - CTS**

- Compression of the median nerve on longitudinal/sagittal view.
- Pre-stress: no compression.
- Stress: median nerve narrowing (58%) maximal site of compression at mid-distal tunnel.

Med DSL = 3.4ms
Radial DSL = 2.5ms
8/13/2015

**DIAGNOSTIC ULTRASOUND OF CTS**

**PRE-Stress**
- Med DML = 5.3ms; 75%CB
- Med DSL = NR

**Stress**
- Median nerve compression (46% narrowing)

**DIAGNOSTIC ULTRASOUND OF CTS**

**PRE-Stress**
- Med DML = 5.3ms
- Med DSL = 4.4ms

**Stress**
- Median nerve compression (41% narrowing)
- Capitate #3 metacarpal

**#3CMC**

**DIAGNOSTIC ULTRASOUND OF CTS**

**PRE-Stress**
- Med DML = 5.3ms
- Med DSL = 4.4ms

**Stress**
- Median nerve compression (41% narrowing)

**DYNAMIC STRESS TESTING OF CTS**

**Longitudinal Imaging - video**

40 y/o female, Left UE pain, numb, tingling, weak, x 3mos, 1st 3 digits, worse at nite+activity. + Tinel/Phalen, palp restric
- Left DML = 5.3ms (ulnar 2.8), DSL (D-1) = 4.4ms 7mcv,
  - needle exam normal

14:44:53 hrs __[0002358].mp4
**Median Nerve Stress Testing for CTS**

(Transverse Imaging)

**Pre-stress**

Compression of the median nerve on axial 'open-mouth' imaging

During dynamic thenar stress

**Stress**

(Median nerve flattening - 36%)
Anatomy of Carpal Tunnel
Variations of Thenar Muscle Attachment

TCL Myofibroblasts in CTS

Electron-microscopy of the TCL
Myofibroblasts detected in the TCL; fibroblasts with properties of smooth muscle cells
Faster growth rate in TCL cells of CTS patients, may be due to cellular response to trauma.

Constant state of contraction:
Decrease in the volume of the carpal tunnel
Increasing pressure on the median nerve


Etiology of CTS

Multifactorial:
1. Increased intracarpal pressure (+ muscle intrusion during activity)
2. Decreased median nerve mobility (fibrous fixation, SSCT adhesions)
3. Median nerve deformation (traction, stretching, compression; SSCT?)
4. Increased 'stiffness' of synovium (and SSCT) and TCL
5. Thenar muscle mass effect + TCL protrusion into the carpal tunnel
6. Flexor tendon thickening and tightening during activity; SSCT 'tethering'?
7. Combine #5-6: direct compression between muscle and tendon

CTS is Not Idiopathic

It does not just ‘happen to you’

It is a self-defense mechanism, nature’s way of protecting itself from overuse:

The activity compresses the nerve supplying the muscle that generates the activity, leading to weakness and atrophy of the muscle, which causes the compression to ‘back-off’, and allows the nerve to recover.

Treatment Implications:

1. Myofascial release
2. Modified thumb spica
3. Botox thenar muscle?
4. Avoid vigorous or sustained grasping/pinching (padded handgrips)


CTS Stress Testing Pre+Post OM

THE ELECTRODIAGNOSTIC REPORT

Report the abnormality (Interpretation):

“…moderate prolongation of the median distal motor and sensory latencies, consistent with slowing across the wrist due to focal demyelination…loss of amplitude consistent with conduction block (or axon loss)…”

Diagnostic ultrasound imaging (high resolution, 4-15MHz linear transducer) of the right wrist reveals moderate increase in the cross-sectional area of the median nerve (18mm²; normal <12mm²) at the level of the pisiform (transverse imaging), and partial loss of fascicular architecture, consistent with nerve edema and carpal tunnel syndrome. The flexor tendons appear normal. Thenar flexion stress test (longitudinal imaging) reveals median nerve compression between the thenar muscles and flexor tendons in the distal carpal canal. Motion studies (transverse imaging) reveal mild lumbrical muscle intrusion into the carpal canal during digit flexion (grasp), with mild median nerve compressive effect; but no muscle intrusion during wrist and digit extension.

Summarize with ‘Impressions’ or ‘Conclusions’:

“Median mononeuropathy (consistent with carpal tunnel syndrome); mild-moderate on the right and mild on the left, electrically”
Ultrasound v. EDX

US is painless, lower cost, less time

US provides detailed anatomic information:
- Muscle atrophy
- Nerve mobility (sliding in sagittal and axial planes)
- Precise localization/extent of edema
- Anomalous nerve branching
- Anomalous muscle penetration into the canal
- Post-op incomplete TCL transection
- Presence of cysts, tumor, persistent median artery

EDX is painful

EDX provides physiologic information:
- Specific – axon v. myelin, CB; prognosis

Both have fairly high specificity and sensitivity for CTS.

Key References:
4. Ahuja AT: Diagnostic and Surgical Imaging Anatomy Ultrasound. Salt Lake City, Amirys. 2007
References:


References (cont):