



CLINICAL NEURODYNAMICS

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Orthopaedic Manual Physical Therapy Series
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Clinical Neurodynamics

- Definition: clinical application of mechanics and physiology of the nervous system as they relate to each other and are integrated with the musculoskeletal function
- Links mechanics, physiology and function of the MS system to the nervous system
- Does NOT just consider tension
 - Sliding
 - Physiology
 - Intraneural blood flow
 - Mechanosensitivity
 - Inflammation of neural tissue



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Effect of clinical neurodynamics

- Restoration of normal **mechanics** of the connective tissues thus lessening the possibility of the nerve being entrapped in their surrounding connective tissue
- Enhancing the **intraneural pressure** in the nervous system and dispersion of **intraneural edema**
- Improve **vascularization** of nervous system and surrounding structures
- Improve **axoplasmic flow**



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Indications for Neurodynamic Testing

- Pts w/symptoms anywhere in the arm, head, LBS, and thoracic spine
- Subjective exam suggests ANTT (Cervical flexion produces LB or LE pain when getting in/out of car)
- Post surgical pts, chronic dysfunctions and symptoms w/o joint signs



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Indications for Neurodynamic Testing

- Symptoms do not fit a normal pattern (arm or leg symptoms not responding to local treatment)
- UE or LE muscle tear
- Post whiplash, CTS, DeQuervains tenosynovitis, tennis elbow, TOS, and repetitive strain injury
 - Clinical example: When testing active shoulder flex/abd and the pt spontaneously performs movement w/elbow flexion and/or cerv SB toward involved extremity

CONTRAINDICATIONS

- Malignancy
- Instability
- Recent worsening of neurological signs/symptoms
- Cauda equina syndrome
- Pathology of the nervous system (e.g. diabetes, MS, Guillian-Barre)



Nervous System: Three Part System

- **Nerve:** peripheral nerve, nerve root, dura
- **Interface:** any tissue adjacent to the nerve
 - Connective tissue
 - Bone
 - Muscle
 - Piriformis: mechanical interface to the sciatic nerve as it pierces or courses just adjacent to it
- **Innervated tissue**



Nervous system primary functions

- Withstand tension
 - 18-22% elongation before failure
 - Varies btw individuals and btw specific nerves
 - Elongation produces a change in blood vessel function—compromises sliding
 - Longitudinal sliding—typically prevents excessive tension
- Withstand Pressure

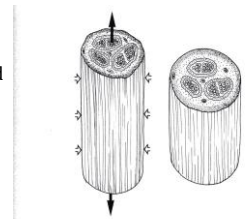
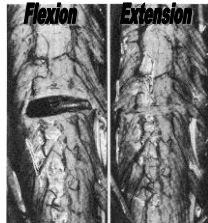
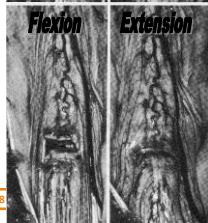


Fig. 2-12 Tension along a nerve will increase the intraneural pressure as the cross-sectional area decreases

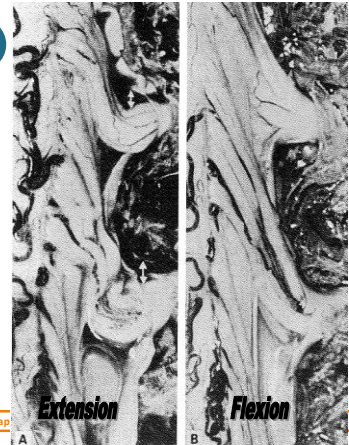
VOMPTI
 Elongation of the cervical spinal cord with flexion and extension



Elongation of the lumbar spinal cord with flexion and extension



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 Normal movement of the spinal cord and nerve roots in the cervical spine with

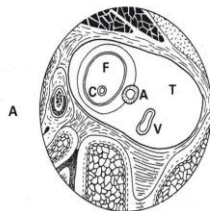


a) Extension

b) Flexion

Tunnel for Nerve, Artery, Vein

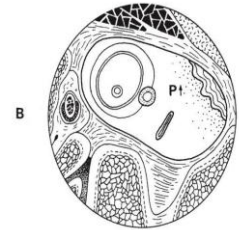
- Normal Pressure Gradient



A Normal tunnel. For adequate nerve fibre nutrition, the pressure gradient must be:
 $PA > PC > PF > PV > PT$

Tunnel for Nerve, Artery, Vein

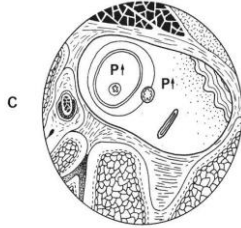
- 8% elongation-- intraneural veins start getting blocked



B Hypoxia. Increased tunnel pressure → Venule collapses
 Venous stasis → Hypoxic axons

Tunnel for Nerve, Artery, Vein

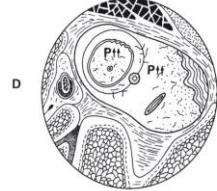
- Edema occurs further increasing intratunnel pressure
- 15%--all blood flow blocked



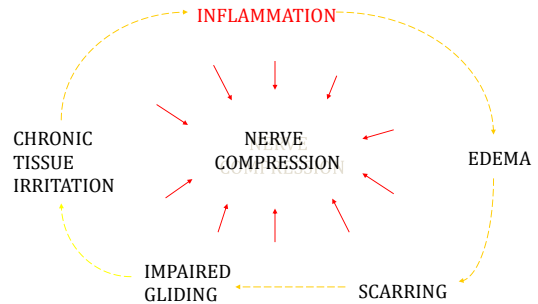
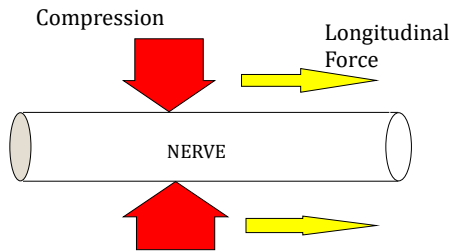
C Oedema. Venous stasis → Deterioration of capillary endothelium → Oedema → ↑Intrafascicular pressure

Tunnel for Nerve, Artery, Vein

- Edema contributes to increased fibroblastic activity



D Fibrosis. Intrafascicular fibroblastic activity → Scar tissue → ↑Pressure, ↑Hypoxia → Segment of nerve becomes fibrous cord → Cycle of Irritation



Nerve Compression

- Disruption of axoplasmic flow due to nerve compression **IS** reversible
- 50 mm Hg x 2 hrs, reversible in 24 hrs
- 200 mm Hg x 2 hrs, reversible in 3 days
- 400 mm Hg x 2 hrs, reversible in 1 week



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Nerve Movement

- 3 ways to move nerves
 - Move the joint
 - Move the actual nerve
 - Move the adjacent soft tissue (muscle, fascia)

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Transmission of Forces Along the System

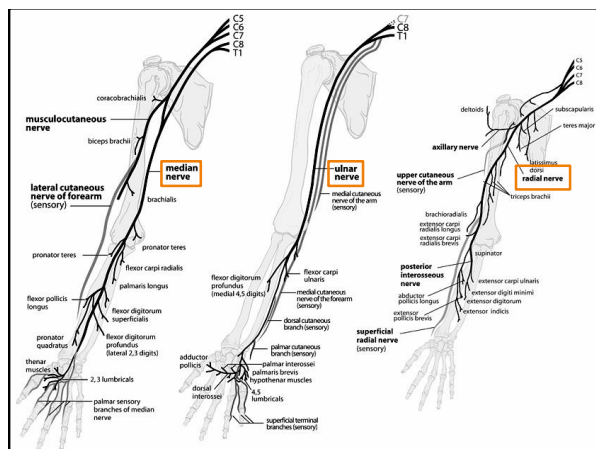
- Neural effects during neurodynamic technique:
 - Early in movement—taking up slack
 - Mid range—sliding effects
 - End Range—tension effects
 - Reference: Wright et al 1996
- Directly translates to treatment progression

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Upper Extremity Nerves

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The Median Nerve

- Muscles innervated
 - Flexor carpi radialis, palmaris longus, pronator quadratus, pronator teres, digital flexors
- Motor functions
 - Thumb flexion and opposition, flexion of digits 2 & 3, wrist flexion and abduction, forearm pronation
- Sensory
 - Skin over anterolateral surface of hand

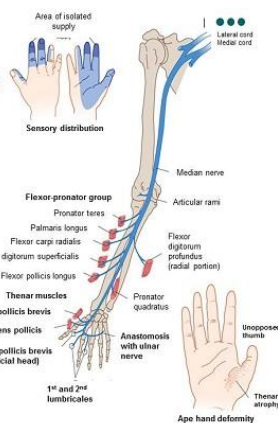
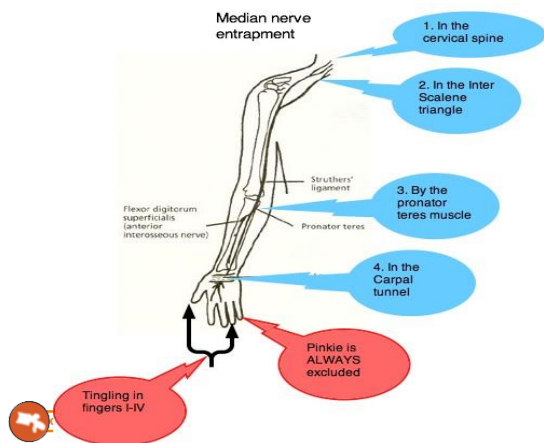


Figure 28-6. The median nerve (C6-8; T1). In Waxman SG. Clinical Neuroanatomy, 26th ed. <http://www.accessphysiotherapy.com>. Accessed May 10, 2011.



UE Neurodynamic Testing

- Upper Limb “Tension” Testing (Provocation)
 - “SLR of the Upper Extremity”
 - Not disorder specific except for a (-) test to rule out cervical radiculopathy
 - Biased to the terminal branches of the brachial plexus based on their anatomy
 - Median nerve (ULTT 1 and 2a)
 - Radial nerve (ULTT 2b)
 - Ulnar nerve (ULTT 3)
 - Sensitivity 72-97%
 - Specificity 22-33%

- Reproducible neurogenic pain (burning or lightning-like pain, tingling sensation, according to dermatome pattern if nerve root pathology) in neck and arm;
- Increased/decreased symptoms with structural differentiation; and
- Difference in painful radiation between right and left sides.



Median Neurodynamic Test1

1. Pistol grip isolate digits
1,2,3- median nerve distribution
2. Therapist hand sits on bed above shoulder using knuckles as a fulcrum. Lean on the hand with a straight elbow. Arm in 90 deg shoulder abduction, elbow at 90 deg flexion
3. wrist ext
4. GH ER to approx. 90 deg. (in frontal plane, stop shoulder from elevating). Do NOT depress scapula



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Median Neurodynamic Test1

- 4. Elbow extension to symptom reproduction or tension
- 5. Cervical SB toward (?symptom ↓)
- 6. Cervical SB away (?symptom ↑)
- *****Structural differentiation:**
 - distal symptoms: use cervical SB toward/away
 - proximal symptoms: use wrist flexion
- Normal response:
 - Symptoms: pulling anterior elbow extending to the first 3 digits.
 - ROM—anything btw 60 deg to full elbow ext



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Median Neurodynamic Test 2

1. Perform shoulder depression taking up slack in nerves with anterior thigh, NOT to the point of stretching.
2. Elbow extension

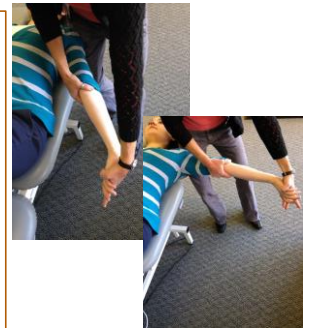


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Median Neurodynamic Test 2

4. External rotation/supination, wrist and finger extension
 5. Shoulder abduction
- ** Structural Differentiation:**
- Proximal symptoms: use wrist
 - Distal symptoms: release shoulder elevation
- Normal response:**
- Symptoms: pulling anterior elbow extending to the first three digits. Sometimes paresthesia in the hand in Median Nerve distribution
 - ROM: anything btw 0-45deg abduction



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Side-to-side range of movement variability in variants of the median and radial neurodynamic test sequences in asymptomatic people

Vaidas Stalioraitis^a, Kim Robinson^b, Toby Hall^{b,c}

Manual Therapy 19 (2014) 338–342

- Evaluation of side to side differences in elbow ROM during ULTT for Median and Radial nerves for onset of resistance (R1) and onset of nerve pain (P1)
- No difference in mean ROM btw sides
- Intra-individual inter-limb differences of **>15° for median** nerve and **>11° for radial** nerve exceeds the range of normal ROM asymmetry of ULTT at R1 and P1



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Neurodynamic Sequencing

- Sequencing of movements influences the location of symptoms
- Greater symptoms at region moved **first and most strongly**
- Ref:Shacklock 1989, Zorn, Shacklock and Trott 1995



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Neurodynamic Sequencing

- Tsai 1995 Cadaver Study on Ulnar nerve
 - Compared tensioning:
 - proximal to distal
 - Distal to proximal
 - Elbow first
- Greatest strain at ulnar nerve at the elbow with the Elbow First sequence (increased intraneural tension by 20%)



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Neurodynamic Sequencing

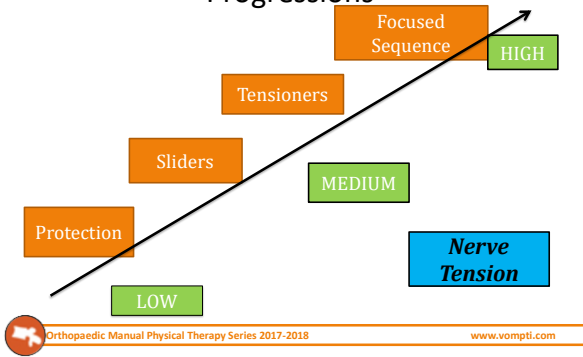
- Technique considerations:
 - Must be consistent with testing
 - If you change technique, you change the test or change the treatment
 - Small technique changes may produce a BIG change in response



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Neurodynamic Sequencing Progressions



Neurodynamic Sequencing

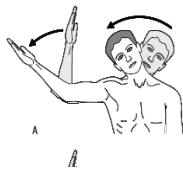
PROTECTIVE REMOTE

- Example: Acute wrist pain
 - 1. Cervical contralateral SB
 - 2. Shoulder abduction
 - 3. Elbow extension
 - 4. Release cervical contralateral SB---"Off Switch" should reduce wrist pain
 - NEVER change wrist position if it is the symptomatic area
- Example: Low back pain
 - 1. Dorsiflexion
 - 2. SLR to onset of pain
 - 3. Release DF---"Off Switch" should reduce back pain

Neurodynamic Sequencing

SLIDER (Median nerve bias)

- Nerve slides toward the site where force is initiated
- Moves both proximal and distal area to floss vs. creating tension on nerve
- Must understand course of nerve to choose correct positioning



Active Median Nerve Slider



Passive Median Nerve Slider

- Wrist flex/elbow ext
- Wrist ext/elbow flex



Slider dosage?

- Allows nerve to return to rest position and never allows reproduction of symptoms during treatment
- Can be repeated several times during a session provided a beneficial response occurs with frequent reassessments
- Can perform 4-5 sets of 5-30 reps w/breaks of seconds to minutes

Slider dosage?

- If negative response, alter technique
- Do not give as HEP until 24 hour response is noted
- May then perform as HEP from 1x daily to hourly dependent upon pt needs
- If cases such as acute HS injury, CTS release, shoulder surgery, and want to inhibit affects of scar tissue lay down, may have pt perform hourly

Neurodynamic Sequencing

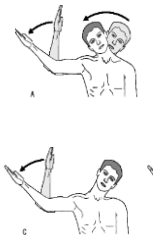
TENSIONER (Median nerve bias)

- Places nerve on tension
- Must understand course of nerve to choose correct positioning



Coppieters et al. Different Nerve Gliding Exercises Induce Different Magnitudes of Median Nerve Longitudinal Excursion: A Study Using Dynamic US imaging. *JOSPT* 2009;39:164-171.

- Different exercises produce different amounts of longitudinal nerve excursion
- (A) "Sliding Technique" produces largest excursion
 - Ipsilateral cervical SB combined with elbow extension
- (C) "Tensioning Technique" produced smaller excursion
 - Contralateral cervical SB combined with elbow extension



Neurodynamic Sequencing

FOCUSED SEQUENCE (Median nerve bias)

- Example 1: chronic cervical pain
 - 1. Cervical contralateral SB
 - 2. Shoulder abduction
 - 3. Elbow extension
 - 4. Wrist extension
- Example 2: chronic wrist pain
 - 1. Wrist extension
 - 2. Elbow extension
 - 3. Shoulder abduction
 - 4. Cervical contralateral SB



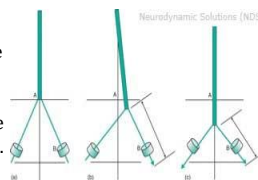
Contralateral Neurodynamic Testing

- Elvey 1979, Rubernach 1985
- 95-97% of young, asymptomatic subjects show a change in symptoms of tension with contralateral neurodynamic positioning
 - 62% show a DECREASE
 - 33% show an increase
 - Approx 5% show no change

Contralateral Neurodynamic Tension

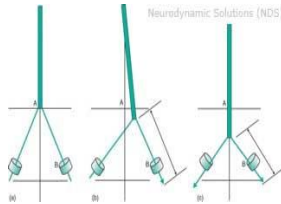
- **Part A** (left), the nerve roots are in their neutral position.
- **Part B** (middle), this ipsilateral nerve root is pulled and tensioned by the first (ipsilateral) neurodynamic test.
- **Part C** (right), the ipsilateral nerve root has loosened because the spinal cord has moved downward by the pulling of the contralateral nerve root with the contralateral neurodynamic test.

Nerve roots as they interact across the spinal cord and produce movement in the cord during contralateral ND tension



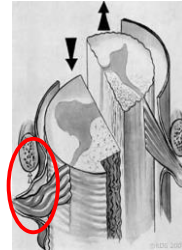
Contralateral Neurodynamic Tension

- permits the ipsilateral nerve root to get looser
- challenges past ideas that contralateral testing produces an increase in neural tension in the ipsilateral nerve root.
- clinicians often notice pts with severe lumbar nerve root pain can get relief with contralateral nerve tension



Contralateral Neurodynamic Tension

- Downward (caudal) movement of the spinal cord producing a reduction in tension in the nerve roots (from Breig 1960, Shacklock 2007).
- Produces a dec in distance between exit point of the nerve root from the spinal cord and the intervertebral foramen
- This results in a reduction in tension in the nerve root.



Slump Test: Effect of Contralateral Knee Extension on Response Sensations in Asymptomatic Subjects and Cadaver Study

- 2 Fold study to compare the response of subjects to contralateral slump test and examine cadaver contralateral LB neural tension
- Control group of asymptomatic subjects had normal thigh stretch reduced w/contralateral ST vs no change in control or sham
- Contralateral reduction in LB neural tension with unilateral nerve root tension in cadaver study
 - Supports proposed hypothesis of reduced contralateral n. root tension in healthy individuals



SPINE: An International Journal for the study of the spine Publish Ahead of Print
DOI : 10.1097/BRS.0000000000001218

Contralateral Neurodynamic Tension

- Often **decreases** nerve root tension
- Can be used to “**offload**” cervical spinal root
- Must be particular on body/limb position
- Can **decrease the power** of a ND technique
- Can change its level of tension/impact
- Can use with normal progression of the neurodynamic test
- UE/cervical “offload”: use contralateral median nerve tension or SLR tension
- LE/LB “offload”: use contralateral SLR nerve tension

Contralateral neurodynamic tension

- R median nerve or cervical nerve root irritability
- R UE held in slack position
- L side tension to further slack R UE tension
- UE median nerve tension position used to "off-load" opposite UE tension



Contralateral Tension Effects - LB Spine

- Reduction in symptoms with contralateral SLR is typical
- Observations in clinical and normal subjects suggest that the effects are **MORE SIGNIFICANT** than in cervical spine
- Possibly because the intradural nerve roots are more parallel and in a better position to assist one another



SLR to Reduce Cervical Nerve Root Tension

- SLR may be used to reduce tension in the cervical nerve roots by moving the cord downward in the canal.
- LE movements can be used to ease pain and mobilize the nerve roots, including thoracic and cervical regions
- LE movements can substitute contralateral upper limb neurodynamic testing



SLR to Reduce Cervical Nerve Root Tension

- If the contralateral UE nerve tension does not relieve a patient's neck and or upper limb pain, the SLR can be applied instead
- It is hypothesized that the SLR pulls the cord downward in the canal which produces a reduction in tension in the cervical nerve root.



Diagnosing with Neurodynamic Testing

- **Structural Differentiation** (nerve sensitizing or desensitizing movement)
 - Used to make a distinction between neural and non-neural structures being the source of symptoms
 - When nerves in a problem area are moved w/o moving MS tissues
 - If symptoms change with the differentiating movement symptoms ARE NEUROGENIC
 - If symptoms do NOT change with the differentiating movement symptoms are NOT NEUROGENIC



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Diagnosing with Neurodynamic Testing

- **Structural Differentiation** (neural sensitizing/desensitizing movement)
 - EXAMPLE: Forearm symptoms with ANTT testing
 - Change nerve tension with cervical SB
 - If symptoms change—most likely neurogenic in origin
 - If symptoms do NOT change—most likely non-neural (muscle, fascia, scar tissue..etc)



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Diagnosing with Neurodynamic Testing

- Performance of test must be:
 - PRECISE
 - Hand positioning
 - Joint ROM
 - Movement resistance
 - Neurodynamic sequence
 - Slow
 - Careful
 - Complete—stop when you encounter first obstacle:
 - Each movement to first comfortable symptoms
 - Resistance



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Diagnosing with Neurodynamic Testing

- Produce response/effect
 - Symptoms
 - Area/distribution
 - Choose differentiating movement
 - Physical
 - ROM
 - Muscle responses
 - Protective movement



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Classification of Responses

- MS response
 - Does NOT change w/structural differentiation movement
 - Neural tissues are not likely source of symptoms
- Normal Neural response
 - **Does** change w/structural differentiation movement
 - Symptoms are similar in location, range of movement and quality of symptoms to normal subjects
 - Reasonably symmetrical in site and quality of symptoms
 - Reasonably symmetrical in ROM and behavior of resistance
 - **Does NOT** reproduce clinical symptoms



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Classification of Responses

- Abnormal Neural response
 - **Does change w/structural differentiation movement**
 - Symptoms are different in location, range of movement and quality of symptoms to normal subjects
 - Reduction in ROM and increased resistance
 - Location and quality of symptoms can be different from unaffected side
 - May be abnormal but NOT reproduce patient's symptoms
 - May indicate a subtle problem worth treating
 - May be hidden sub-clinical abnormality



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Classification of Responses

- Abnormal Neural Response Example
 - Pt has cc/o forearm pain with computer use
 - “ache” during ANTT at region of the problem but does not reproduce exact pain
 - Structural differentiation: neural w/cervical contralateral SB
 - ROM of elbow ext < unaffected side
 - Supination < unaffected side that improves with releasing cervical SB
 - Signs are **relevant** --missing them limits effective treatment



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Relationship of Neurodynamic Testing Results to the Cause?

- Abnormal ND test does **NOT** establish cause
- **SOMETHING** in nervous system is wrong and cause must be established through thoroughly evaluating the pt
- Main thing that an abnormal neurodynamic test offers is the fact that something in the nervous system is wrong and the cause needs to be established



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Relationship of Neurodynamic Testing Results to the Cause?

- Possible causes of abnormal ND test:
 - Pancoast tumor or malignancy
 - Osteophyte
 - Disc bulge
 - Swollen joint or tendon sheath
 - Myotendinous or nervous system anomalies
 - Neuritis
 - Nerve compression
 - Joint movement dysfunction



Analysis of Test Responses

- Once you have decided the test is positive (via structural differentiation)
 - Are those the symptoms you have had before?
 - Yes-abnormal response
 - No-perform stage 2 test
 - Is the response similar to the known normal response?
 - ROM, tissue resistance, location, type of symptoms normal?
 - Yes- normal positive test
 - No-abnormal response
 - Not sure?—compare to contralateral side
 - ** any variable used in classifying the response must be positive to structural differentiation



Analysis of Test Responses

- Is it Relevant?
 - Relevant:
 - Reproduces pts current clinical pain
 - Is tighter than normal
 - The symptoms spread further than normal
 - This is different from asymptomatic side
 - The difference is in the right location of the pt problem



Analysis of Test Responses

- Is it Relevant?
 - Irrelevant:
 - Relates to an old problem that is no longer symptomatic
 - Anomalous response that is symmetrical (ie. Bilateral tightness)
 - Normally tight for that person and is symmetrical
 - May have anatomical anomaly that is not relevant



Wainner RS, Fritz JM, Irrgang JJ et al. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. *Spine* 2003;28:52-62.

- 82 pts referred for electrophysiologic labs with suspected CR or CTS
- Examined Pt self report, NCS/EMG, and clinical exam
- Test item cluster of 4 variables was identified and produced a positive likelihood ratio of 30.3 for the pt having CR
 - 4 clinical exams: (+) Spurlings A, (+) Distraction test, (+) ULTTA, involved cervical rotation < 60 degrees
 - Probability of condition (CR) is 65% with 3 out of 4, 90% with 4 out of 4

Planning Exam and Treatment

- Multi-Level System of deciding the extent of Exam:
 - Level 0: Neurodynamic Testing
Contraindicated
 - Severe Pain
 - Psychological Influences
 - Legal problems
 - Highly unstable condition, worsening rapidly



Multi-Level Exam System

Level 1: Limited

- Indications
 - Pain easily provoked, highly irritable
 - Severe or latent pain
 - Pathology is present in nervous system or mechanical interface (HNP pressing on nerve root)
 - Progressive worsening prior to physical exam

Multi-Level Exam System

Level 1: Limited (cont)

- Method
 - Some components or ROM may be omitted to apply less forces on nervous system
 - Sequencing can be altered (ie, remote alteration vs. focal)
 - Restricted to first onset of symptoms, once only
 - Structural differentiation is still performed, but in modified form

Multi-Level Exam System

- Level 1: Limited (cont)
 - Modified Structural Differentiation:
 - Used as an “off” switch to REDUCE symptoms
 - Instead of additional movement which adds tension
 - Clinical example: Irritable wrist problem
 - Cervical contralateral SB
 - Shoulder abduction
 - Elbow ext
 - Structural differentiation (off-switch)—neck back to neutral
 - Do NOT move irritable area (wrist)



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Multi-Level Exam System

- Level 2: Standard
 - Neurodynamic tests are performed to a comfortable production of symptoms only
 - May be, but not necessarily taken to end range
 - Indications:
 - Problem not particularly irritable
 - Neuro symptoms are absent or minor part of condition
 - Symptoms not easily provoked
 - Problem is stable (not deteriorating rapidly)
 - Pain not severe and no severe latency of symptom provocation

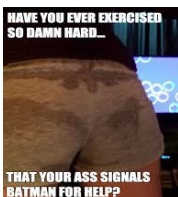


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Multi-Level Exam System

- Level 2: Standard
 - Method:
 - Test movements would not produce excessive pain, neuro symptoms or go into a great deal of resistance
 - Standard neurodynamic tests are used
 - Full Range of movement may be reached, but is not essential



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Multi-Level Exam System

- Level 3: Advanced:
 - Testing of nervous system more extensive and advanced than previous levels
 - Specificity and sensitivity are the focus
 - Indications:
 - Level 2 exam tests are normal and do not provide useful info
 - Problem is stable
 - Patient's clinical pain is difficult to reproduce
 - No evidence of pathology that might adversely affect nervous system.
 - **** If sufficient info is gained from Level 1 or 2 exam, Level 3 is unnecessary and contraindicated**



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Multi-Level Exam System

- Level 3: Advanced:
- Method:
 - Level 2 test performed first (to be sure nervous system can cope w/further testing) and does NOT reproduce symptoms
 - Add sensitizing movements
 - Can alter sequencing to begin with provocative area first
 - Combine sensitization of neural structures with MS ones
 - Can use functional positions or activity to reproduce symptoms (ie, throwing)



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Level 3 Test Example

- Assessment technique of pt
- The patient performs a throwing position so as to reproduce the mechanism of symptoms.
- The therapist can refine the shoulder position or resist any chosen movement while altering the differentiation movements (wrist flex/ext and cervical SB) to detect a hidden neurodynamic component.



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