Am I Missing Something?

**COMPREHENSIVE CERVICAL SPINE MANAGEMENT**

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Neck Impairments after Whiplash

- Most impairments will resolve within days or weeks
- But there is a small percentage who don’t resolve
- Go on to have chronic condition: Whiplash Associated Disorder (WAD)

Clinical Practice Guidelines

Neck Pain:
Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association

Cervical Pain

- Pain Resolves
- Chronic, Non-dizzy
- Chronic-Dizzy

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p. 1
Kinesthetic Retraining
- Standard after ankle sprains
- Why should the cervical spine be any different?

LE sensory polyneuropathy
- Expected unsteadiness, ataxia, loss of balance, decrease in function, increased disability
- Reduce or remove visual input ➔ increased findings
- Question: would loss or change in cervical sensory input ➔ similar findings?

Sensory Organization
- Determination of Body Position
- Compare, Select & Combine Senses
- Visual System
- Vestibular System
- Somatosensation
- Interaction with the Environment

Cervical Somatosensation
- Unique from other region
- Serves to:
  ◦ Confirm vestibular and visual inputs regarding head position and movement
  ◦ Position the vestibular and visual systems by guiding head position
- Upper cervical region has more connections to the visual and vestibular systems compared to lower cervical segments

Imagine how you would feel...
If you turned your head, and:
- Your eyes told you that your head had just moved 10 degrees...
- And your ears told you that your head had just moved 10 degrees...
- But your cervical somatosensory inputs were telling you that you’d moved only 5 degrees...

Imagine how you’d feel...
- I’m not sure where my head is...
- I feel spacey...
- I feel off...
- I feel lightheaded...
- I feel imbalanced...
- I feel ????
Proposal

Cervicogenic dizziness results from a sensory mismatch between somatosensory information from the cervical spine and input from the visual and vestibular systems.

The Problem with the term Cervicogenic Dizziness

Altered Receptor Sensitivity

Chemical changes due to inflammation, ischemia

Muscle impairments:
- Reflex joint inhibition of muscle spindles
- Increased fatigability
- Degenerative changes

Pain at various CNS levels:
- Changes muscle spindle sensitivity
- Alters cervical representation of cervical afferent input

IS THERE SOMETHING ABOUT THESE PATIENTS THAT MAKES THE PAIN AND DISABILITY PERSIST?

Risk Factors for Persistent Problems

- Poor prognosis after whiplash injury
- Catastrophizing
- WAD grade 2 or 3
- Presents with HA
- Baseline neck pain >55/100 or 6/10
- NDI > 15/50
- History of previous neck pain
- Female gender
- NDI > 15/50

Walton et al. 2013 JOSPT
Risk Factors for Persistent Problems

- Poor prognosis after whiplash injury
- Presence of LBP at baseline
- Catastrophizing
- History of previous neck pain
- Female gender
- WAD grade 2 or 3
- < post-secondary education
- Baseline neck pain >5/100 or >6/10
- NDI > 15/50

Management Goal

- Pain Intensity?
- No Post-secondary Ed!
- Causes of chronicity
- Sensorimotor impairments?
- Headache?
- Chronic Condition

LITERATURE REVIEW

Basing patient management on the best available evidence

“The Science of the Art of Medicine”

Clinical Expertise

Best Evidence

Patient’s Values & Circumstances

Evidence-Based Practice (EBP)
Causes of disturbed cervical afferent accuracy

Given: Somatosensory cervical input converges with vestibular input in order to mediate multisensory control of orientation, gaze in space, and posture. Therefore, in theory, cervical impairments could result in
- symptoms of perceptual disorientation
- ocular motor signs, and
- postural imbalance

What appears to be useful so far?
- Measures of postural control
- Cervical repositioning accuracy
- Measures of oculomotor control when the head is turned
  - Smooth pursuit
- Combinations of the three

Sensorimotor
- The term sensorimotor describes all the afferent, efferent, and central integration and processing components involved in maintaining stability in the postural control system through intrinsic motor-control properties.

Therefore: need to establish reliable measures of:
- Perceived vertical
- Subjective straight ahead
- Subjective head to trunk position
- Oscillopsia
- Oculographic measurement of resting eye position, gaze in space, and nystagmus
- Posturographic measurements, cervicospinal reflexes, and analysis of gait.

ASSESSMENT OF SENSORIMOTOR DEFICITS

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Sensorimotor
- The term sensorimotor describes all the afferent, efferent, and central integration and processing components involved in maintaining stability in the postural control system through intrinsic motor-control properties.
Patients with cervical trauma

- In addition to pain and loss of ROM will manifest some or all of the following:
  - Impaired postural control, manifested by increased sway.
  - Impaired cervical muscle function (extensors as well as flexors), including strength, control, and endurance.
  - Impaired cervical kinesthetic ability, manifested by increased joint position error.
  - Impaired oculomotor function, manifested by a positive smooth pursuit neck torsion test.
  - Hypersensitivity to temperature.
  - Post-traumatic stress

Sensorimotor deficits

Disturbance in Postural Stability

- Patient complains of:
  - Unsteadiness
  - Insecurity
  - Lightheadedness (not presyncope)
  - Complaints worsen with head movements, fatigue
  - NOT vertigo (“spinning”)

Sensorimotor deficits

Disturbance in Postural Stability (cont)

- Assessment
  - Exclude vestibular etiology
  - Head-Neck Differentiation test
  - Comfortable stance
    - Eyes open (eo)
    - Eyes closed (ec)
  - Narrow stance eo and ec
  - Repeat each on foam
  - Single limb stance
  - Tandem stance (hard for healthy elders)
  - 10 m walk with head turns (15 steps in 8 sec)
  - Consider adding vibration to the head or neck

Sensorimotor deficits

Disturbance in Neck movement control

- Patient complains of:
  - Head feels heavy
  - Neck is tired
- Assessment
  - Quality of movements
  - Trace intricate patterns on wall with laser on head
  - Deep cervical flexor function
  - Cervical extensor endurance

Sensorimotor deficits

Disturbance in Head-neck awareness

- Patient complains of:
  - Wobbling head, spacey, floating;
  - Lightheaded but not pre-syncope
- Assessment
  - Joint position error (JPE) aka head repositioning accuracy

Sensorimotor deficits

Disturbance in Oculomotor control

- Patient complains of:
  - Blurred vision, reduced visual field, photophobia
- Assessment
  - Exclude central vestibular causes
  - Smooth pursuit with neck torsion
  - Gaze stability
  - Saccades
  - Eye-head coordination
Patients with cervical pain
• In addition to pain and loss of ROM will manifest some or all of the following:
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Kristjanssen 2009

**Postural Control**

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Sensory Organization

Assessing postural stability
• Perform a combination of the following static tests for standing postural stability.
• Assess for
  ◦ duration (30 seconds), and
  ◦ quality of movement and stability (amount of sway)
• Try adding vibration to the head or neck (bony prominences) and assess any changes that are produced by the addition of the vibration.

Assessing postural stability

<table>
<thead>
<tr>
<th>Stance</th>
<th>Vision</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfortable</td>
<td>Eyes open</td>
<td>Firm</td>
</tr>
<tr>
<td></td>
<td>Eyes Closed</td>
<td>Foam</td>
</tr>
<tr>
<td>Narrow</td>
<td>Eyes open</td>
<td>Firm</td>
</tr>
<tr>
<td></td>
<td>Eyes Closed</td>
<td>Foam</td>
</tr>
<tr>
<td>Single Limb*</td>
<td>Eyes open</td>
<td>Firm</td>
</tr>
<tr>
<td>Tandem*</td>
<td>Eyes open</td>
<td>Firm</td>
</tr>
</tbody>
</table>

*Single limb stance (Do not allow unweighted leg to touch the stance leg)
**Tandem stance hard for elders even when healthy
Add Vibration

Assessing dynamic postural control
- 10 meter walk with head turns
- Normal is 15 steps in 8 sec for ages 43 and up
  - unknown for younger ages

Considerations
- When challenged functionally (for example, with balance tasks), patients with neck pain may use inappropriate increased neck muscle activation in order to achieve stabilization or due to guarding.
- This augmented muscle tension of already tense muscles may further alter cervical afferent input, exacerbating their condition.
- Thus, the appropriate initial level of challenge, and appropriate rate of progression, is necessary.
Considerations
- Proceed from static to dynamic challenges
- Balance retraining can take place concurrently with other interventions to the neck
- Vary the stance, vision, and surface conditions (see above) to achieve a suitable level of challenge

Stop the clock!

Step stance on foam

Patients with cervical pain
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IMPAIRED MUSCLE FUNCTION

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Whiplash
- Incidence: 25% of all MVA’s (Luxon 1996)
- Disruption of upper cervical afferent input
  - Chemical changes due to ischemia or inflammation
  - CNS changes in muscle spindle sensitivity
  - Reflex joint inhibition of the muscle spindles
  - Psychosocial distress (via SNS)
- Altered cortical representation of cervical afferent input

Factors altering muscle afferents
- Functional muscle impairment
  - Increased fatigability
- Degenerative changes, such as
  - Fiber transformation
  - Fatty infiltration
  - Atrophy of the neck muscles
- May alter muscle proprioceptive capabilities, joint mechanics, and muscle spindle sensitivity

Cross sectional area

Images courtesy James Elliott, PT, PhD
Northwestern University

Image courtesy James Elliott, PT, PhD
Northwestern University
Upper cervical region

- High in muscle spindles
- Direct access to vestibular nucleus and central cervical nucleus
  - Vestibular, ocular, proprioceptive integration

Poor muscle function

- Deep cervical flexors are poorly recruited compared to superficial flexors (Jull)
- Cervical extensors are more susceptible to fatigue in some patients (Stapely)
  - Those who demonstrate increased fatigue also demonstrate increased postural sway

Muscle Contribution

- Muscle fatigue
  - Modifies discharge of sensory receptors and affects proprioception
    - May contribute to increases in body sway
  - Subjects show increased sway when their muscles are fatigued, compared to those whose muscles don't fatigue.
  - Neck weakness, among other impairments (ROM, segmental mobility, soft tissue mobility and flexibility, etc), should be examined in patients with a suspected cervical component to their dizziness.
  - We'll return to this in Management:
    - After treatment, these subjects showed no signs of fatigue, and no imbalance.

Cervical Extensors

- N=13, neck pain or neck tension, whiplash injury at least one year prior to the study.
- No central or peripheral nervous disorders, nystagmus, or peripheral neuropathies.
- Sway
  - before, immediately after, 5 minutes after fatiguing isometric exercise
  - Muscle action was measured using EMG
  - Self-rated stability, dizziness, neck pain.

Results

- 2 groups were identified based on EMG: those that fatigued (n=7) and those that did not (n=6).
- Sway was increased in patients with fatigue, but not in those without fatigue.
- Part 2: Post-Intervention measurements
Assessing Muscle Function

Traditional Manual Muscle Test
- Supine flexion in hook-lying
  - 3/5 against gravity
  - Hold, and time (30 sec?)
- After full flexion, extend head
- Then add resistance
  - Offer posterior support!
  - Cervical flexors: push against forehead.
  - Capital flexors: push up against chin.

Assessing Muscle Function

Craniocervical Flexion Test
- Use an inflatable bladder, with pressure gauge, under cervical lordosis
- Patient flattens lordosis, pushing into the bladder

Assessing Muscle Function

Prone on Elbows
- Capital Extensors
- Hold neutral spine, both cervical and thoracic (top photo)
- Duration of hold?
  - 30 sec min
  - Up to 2 mins?

INTERVENTION: IMPROVE MUSCLE FUNCTION

Intervention: Muscle function
- Aimed at reducing cervical discomfort and strengthening of the neck muscles
  - soft tissue treatment, isometric and isotonic exercises, passive and active mobilization in the non-painful range, head traction, relaxation techniques, and postural education.
- Results
  - After treatment, no signs of fatigue or imbalance were found, for the same levels of muscle contraction.

Treating Muscle Function

- Endurance and Strength Training of the Flexors (Falla 2006)
- Patients with chronic non-severe neck pain
- An endurance-strength exercise regime for the cervical flexor muscles is effective in:
  - reducing EMG manifestations of superficial cervical flexor muscle fatigue
  - increasing cervical flexion strength
Endurance/Strength program

- 6 weeks, 10-20 min/day BID, no pain, smooth control
- Endurance-strength group: PRE of supine head lift through full ROM
  - Stage 1 (2 wks): 12-15 reps of 12 RM load, progress to 15 RM
  - Stage 2 (4 wks): 3 sets of 15 reps at original 12 RM load.
  - Load increased with 0.5 KG increments; decreased with head incline

Falla 2006

Endurance/Strength program

- Cranio-cervical flexion exercise (deep upper cervical flexors)
  - Supine progressive cranio-cervical flexion, with SCM, Ant Scalenes relaxed
  - Then trained to hold progressively increasing ROM using pressure bladder
- Both groups: improved pain, decreased disability
- Endurance-strength training group increased MVC force, decreased superficial muscle fatigue

Falla 2006

Train to improve cervical extensor muscle endurance

- Consider using Theraband while prone on elbows.
- To decrease the demand, start in an upright position (sitting)
- Work up to 3-minute holds (longer for high demand individuals (athletes))
- Start with isometric holds in midline, progress to multi-angle isometrics, then single plane movements, and finally multi-plane movements.

EXERCISES TO IMPROVE NECK MOVEMENT CONTROL

EXERCISES TO IMPROVE NECK MOVEMENT CONTROL

EXERCISES TO IMPROVE NECK MOVEMENT CONTROL

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Kristjanssen 2009

Impaired somatosensation

- Revel 1991
  - Changes in cervicocephalic kinesthesia in patients with cervical pain
- Cervical repositioning accuracy
  - Those with more pain have poorer repositioning sense (Kristjanssen 2003)
  - Can be treated effectively (Kristjanssen 1994)

Assessing Cervical Joint Position Error (JPE): Laser
Transform the error from distance to degrees

Example: 7 cm error

The error in degrees is the arctan (or tan^(-1)) of 7/90, or 4.4°

Joint Position (degrees)
Target distance 90cm from head rotation axis

Healthy normal <4.5° JPE

Download a calibrated target at www.skillworks.biz

Head Rotation JPE test

Intervention: Cervicogenic Dizziness Revel 1994
- Improvement in cervicocephalic kinesthesia after proprioceptive rehabilitation program in neck pain patients
- n = 30 controls, n = 196 patients (rehab group)
- 8 weeks, 2 times per week
- Directed by a physical therapist
Results

Revel 1994

- Better head repositioning accuracy
  - before treatment
  - compared to the control group
- Reduced pain (vs. controls) on VAS
- Better cervical rotation
- Self-rated functional improvement
  - 118 (60%) in rehab group: good or very good
  - 8 patients (27%) in the control group (p=0.01)

Components of cervical kinesthesia rehab program

- Slow passive supine head movement, eyes fixed on a target
- Follow a moving target using alternatively slow pursuit and saccades, with free eye and head movement.

All but foveal vision is blocked

- Sitting and standing exercises with restricted peripheral vision
  - Active head movements following a slow moving target
  - Active head movements to maintain gaze on a fixed target while the trunk is passively moved
  - Fix on a target and memorize the head position, then close eyes, perform maximal rotation, return to the starting position, and open eyes.

Head still, eyes fixed on target as body moves underneath
• Eyes open, find target
• Close eyes
• Rotate head fully
• Return head to “look” at target
• Body is fixed throughout
• Open eyes and correct head position if necessary

• As patient progresses, increase difficulty
• Here, add
  ▪ Standing
  ▪ Unstable surface
• Note safety measures

Progression
• Increase speed
• Multiple movements
• Targets off center
• Multiple targets
• Diagonal planes
• Sitting to standing
• Stand on firm to stand on foam
• Standing to walking (dynamic)

Head is moving
• Eye-head coordination
  o Isolate eye and head movements (one is still on target while other is moving)
  o For visual targets, use something that requires focus (e.g. words, graphics)
  o Use laser to get head pointed accurately at target
• Laser on target while body moves underneath (head-neck dissociation)
Patients with cervical pain

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Kristjanssen 2009

Impaired oculomotor function

- Smooth Pursuit Neck Torsion (SPNT)
- Compare gain (target vs. eye speed) of smooth pursuit with neck neutral or head turned 45°
- Neck rotation gain reduced in patients with WAD, but not different in patients with central vertigo, Meniere's, or in healthy controls

Tjell et al. 1998

Smooth Pursuit Neck Torsion Test (SPNT)

- WAD with c/o dizziness:
  - Sensitivity of 90% (SnNOut)
    - If their gain is the same in neutral and in rotation, they DO NOT have WAD
  - Specificity of 91% (SpPin)
    - If their gain is different in neutral versus rotation, they DO have WAD
- WAD without dizziness:
  - Sensitivity of 56% (SnNOut)

Tjell et al. 1998
Combining joint position error, SPNT, and balance tests

- Significant (weak-to-moderate) correlations between all comfortable stance balance tests and both the SPNT and rotation cervical JPE tests.
- Weak correlation between the SPNT and rotation cervical JPE.
- An abnormal rotation cervical JPE score: ability to determine abnormality in balance and or SPNT test
  - high positive prediction value (88%) but
  - low sensitivity (60%) and specificity (54%)

(Treleaven et al. 2005)

Combining joint position error, SPNT, and balance tests

- The results suggest that in patients with persistent WAD, it is not sufficient to measure JPE alone. All three measures are required to identify disturbances in the postural control system.

(Treleaven et al. 2005)

Clinical Examination

- No way at present to measure in clinic
- Clinical assessment:
  - Move a card with writing on it in front of patient sitting with head in neutral
    - Patient reads card
  - Repeat with body rotated under head
  - Questions? Refer out
    - Audiologist can do smooth pursuit

Training Oculomotor control

- Turn assessments into treatment
- Two types:
  - head is stationary or
  - head is moving

Stationary head, only eyes move

- Smooth pursuit: eye tracking of a moving target with head still
  - in neutral and
  - with neck torsion
- Good for early (acute) stages
  - Less provocative
Head is moving

- **Gaze stability**: eyes on stable target, move head towards difficult directions
  - Use targets that need focus, e.g., words, graphics
  - Alter speed, ROM.
- Sitting to standing to dynamic (walking)

Differentiating the difficult presentation

- Complaints are of non-specific nature or vague in description;
- No central signs
- No positional provocation on history or PE (BPPV)
- Objective tests are equivocal

Unclear source of symptoms

- Use a simple separation: “head” vs. “neck” involvement.
- Purpose: try to differentiate the source of the symptoms as coming from the “head” (vestibular, either central or peripheral) or from the “neck” (cervicogenic dizziness, VBI).

Mechanical Differential Diagnosis

<table>
<thead>
<tr>
<th>“Neck”</th>
<th>“Head”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebrobasilar artery insufficiency</td>
<td>Vestibular apparatus: BPPV, peripheral vestibular disorder</td>
</tr>
<tr>
<td>Upper Cervical Region: Joint receptors, muscle spindles, nerve root, autonomic system, proprioceptors, etc.</td>
<td>Central lesions: CNS involvement, fracture, central visual-vestibular abnormalities</td>
</tr>
<tr>
<td>Brainstem</td>
<td></td>
</tr>
</tbody>
</table>

Neck Torsion Nystagmus Test

- Shown not to be specific (see Wrisley 2000)
- Modified
- Applied to other motions
  - Flexion/Extension
  - Quadrant
  - Provocative positions
**Patient Example**

AROM rotation → dizziness

---

**Head Still, Neck Moves**

Example: Rotate body underneath head

- **Positive Findings**
  - Neck is positive
  - Head is unknown: can’t rule out vestibular system
- **Negative Findings**
  - Neck involvement is not suspected
  - Head is unknown: can’t make a statement about vestibular involvement

---

**Start position, trunk/neck rotation under stable head**

---

**End position, trunk/neck rotation under stable head**

---

**Neck Still, Head Moves**

Example: Rotate head and neck together

- **Positive Findings**
  - Head is positive: suspect vestibular system
  - Neck is unknown: can’t rule out cervical involvement
- **Negative Findings**
  - Head (vestibular) involvement is not suspected
  - Neck is unknown: can’t make a statement about cervical involvement

---

**Start position, Head/Neck stable**

---
### Cervical vs. Capital?

<table>
<thead>
<tr>
<th>Positive Findings</th>
<th>Negative Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck Still, Neck Moves</td>
<td>Neck Not Ruled Out</td>
</tr>
<tr>
<td>Head Not Ruled Out</td>
<td>Vestibular System</td>
</tr>
<tr>
<td>Vestibular Positive</td>
<td>Vestibular Not Ruled Out</td>
</tr>
</tbody>
</table>

**Example #2**

**Extension → Dizziness**

- Start position, head/neck stable
- End position, posterior trunk lean with head/neck stable

**Start position, trunk flexion/neck extension under stable head**

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End position, trunk flexion/neck extension under stable head

How to make sense of all this data
- The Important Questions
- What is the functional relevance of neck afferent input?
- How does the lack of, or distortion of, such input lead to vertigo or dysequilibrium?

LE sensory polyneuropathy
- Expected unsteadiness, ataxia, loss of balance, decrease in function, increased disability
- Reduce or remove visual input ➔ increased findings
- Question: would loss or change in cervical sensory input ➔ similar findings?

Experience from other joints
- Joint position sense is impaired after injury and with pain at the:
  - Ankle*
  - Knee
  - Hip
  - Lumbar spine*
  - Shoulder
- *Re-training kinesthetic awareness reduces re-injury rate;
- Failure to retrain results in increased chance for re-injury

Incidence and Prevalence
- Thus, just because the patient doesn’t complain of “dizziness” post whiplash injury doesn’t mean the following impairments should be overlooked:
  - Decreased postural control
  - Increased sway on CTSIB, SLS, tandem stance
  - Oculomotor abnormalities with the head in different positions
  - Positive smooth pursuit neck torsion test
  - Dynamic Visual Acuity test (DVA)
  - Increased joint position errors
  - Muscle function

Cervical Pain
- Pain Resolves: 15%
- Chronic, Non-dizzy: 80%
- Chronic-Dizzy: 5%
Conclusions?

It seems clear that patients with persistent symptoms after a whiplash injury should be evaluated for:
• Vestibular abnormalities, both Central and Peripheral
• Smooth pursuit accuracy
• Postural control
• Neck joint repositioning
• Neck muscle endurance

Conclusions?

It seems clear that patients with complaints of dizziness and imbalance should be evaluated for:
• Cervical Impairments
• Neck joint repositioning
• Neck muscle endurance

Conclusions?

1. Assess the cervical spine in your dizzy and imbalanced patients
2. Assess balance and vestibular function in your cervical spine patients

Conclusions?

U/C Manipulation: Affect on balance

Case Study

Single Intervention Outcome

Initial visit

I Week later
Thank You!

Upcoming Courses

Cervicogenic Dizziness
- Legacy Meridian Park Medical Center
  near Portland, OR
  September 27, 28, 29

- SentraState Healthcare System
  Freehold, NJ
  November 1-3, 2013

- University of Minnesota
  Minneapolis, MN
  March 28-30, 2014

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