

# Positive Cervical Artery Testing in a Patient with Chronic Whiplash Syndrome: Clinical Decision-Making in the Presence of Diagnostic Uncertainty

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David L. Graziano, PT, DPT, MTC  
Wanda Nitsch, PT, PhD, MTC  
Peter A. Huijbregts, PT, DPT, OCS, FAAOMPT, FCAMT

**Abstract:** This case report describes the diagnosis and management of a 43-year-old female patient who had sustained an injury to her neck in a motor-vehicle accident two years earlier. The major symptoms described by the patient included headache and neck pain, but history and examination also revealed signs and symptoms potentially indicative of cervical artery compromise. Physical therapy management initially consisted of soft tissue and non-thrust joint manipulation of the lower cervical and thoracic spine, specific exercise prescription, and superficial heat. Cervical vascular compromise was re-evaluated by way of the sustained extension-rotation test. When at the fifth visit this test no longer produced symptoms potentially indicative of vascular compromise, upper cervical diagnosis and management consisting of soft tissue and non-thrust joint manipulation was added. A positive outcome was achieved both at the impairment level and with regard to limitations in activities, the latter including increased performance at work, a return to previous reading activities, improved length and quality of sleep, and greater comfort while driving. At discharge, the patient reported only occasional pain and mild limitations in activities. This report describes the positive outcomes in a patient with chronic whiplash syndrome; however, its main emphasis lies in the discussion and critical evaluation of clinical reasoning in the presence of diagnostic uncertainty with regard to cervical artery compromise.

**Key Words:** Whiplash Syndrome, Physical Therapy, Cervical Artery, Vertebral Artery, Diagnostic Uncertainty, Clinical Reasoning

In the United States alone, over one million people annually incur acceleration-deceleration or whiplash injuries to the cervical spine<sup>1</sup>. Cervical spine trauma is estimated to occur in 20% of motor-vehicle accidents<sup>2</sup>. Headache and neck pain are common complaints after a whiplash injury but symptoms may also include thoracic, temporomandibular,

facial, and limb pain and stiffness, dizziness, nausea, visual disturbances, tinnitus, malaise, dysequilibrium, anxiety, and depression<sup>3-9</sup>.

There is significant controversy with regard to the natural history of whiplash-associated disorder (WAD). Based on prospective inception cohort studies, prevalence for chronic neck pain in patients with whiplash injuries of 14–42% has been reported<sup>10</sup>. Barnsley et al<sup>10</sup> also noted that approximately 10% of these patients report indefinite but constant and severe pain. A more recent prospective cohort study<sup>11</sup> similarly found that only 51.7% of subjects reported being recovered at 2 years. In contrast, Partheni et al<sup>12</sup> reported a 90% recovery rate in a prospective cohort of patients with grade I and II WAD at a 4-week follow-up. Obelieniene et al<sup>12</sup> reported no between-group differences at a 1-year follow-up for a prospec-

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Address all correspondence and requests for reprints to:

David L. Graziano  
Director of Spine Care  
Balistreri & Associates Physical Therapy  
1135 Prairie Drive  
Racine, WI 53406  
E-mail: Dgraziano3@wi.rr.com

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tive cohort of patients with WAD and matched controls with regard to frequency and intensity of neck pain and headache. This controversy clearly positions clinicians and researchers who regard chronic whiplash syndrome as a mainly cultural and psychosocial phenomenon against those who consider it to be at least partly related to ongoing neuromusculoskeletal dysfunction and, therefore, amenable to physical therapy and medical management.

Neuromusculoskeletal lesions implicated in the etiology of chronic WAD include dysfunctions of the cervical zygapophyseal joints, disks, cartilaginous endplates, muscles, ligaments, vertebrae, and nervous systems structures including nerve roots, spinal cord, brain, and sympathetic nervous system, temporomandibular joints, acromioclavicular joints, the peripheral vestibular system, and—most importantly for this case report—the cervical arteries including the internal carotid and vertebral arteries<sup>10,14-25</sup>. Kerry and Taylor<sup>25</sup> suggested whiplash injury as a cause of intimal injuries to the cervical arteries, predisposing these arteries to subsequent dissection. In a retrospective analysis, Beaudry and Spence<sup>24</sup> attributed 70 of 80 traumatically induced cases of vertebrobasilar ischaemia to motor-vehicle accidents. There is an absence of data on the diagnostic or predictive validity for commonly used history items or physical tests or even clear criteria as to what constitutes positive history or physical examination findings indicative of cervical artery compromise. At the same time, because of the potential for traumatically induced cervical artery dysfunction, the clinician is faced with diagnostic uncertainty when dealing with patients with WAD who report symptoms potentially related to vertebral or internal carotid artery dysfunction.

The goal for this case report was to describe and critically evaluate the physical therapy diagnosis and management of a patient with chronic post-whiplash complaints who presented with signs and symptoms potentially indicative of cervical artery compromise. Cervical artery in this case report is understood to include both vertebral and internal carotid arteries.

## Patient Examination

The examination of this patient followed the format proposed by Paris and Loubert (Table 1)<sup>26</sup>.

### *Pain Assessment*

For pain assessment, the body diagram, the McGill Pain Questionnaire (MPQ), and numeric pain rating scales (NPRS) were used. On the body diagram, the patient indicated pain in the superior, lateral, and posterior aspects of the head and the posterior cervical area bilaterally. On the MPQ, which has been demonstrated to be a reliable and valid method for

**TABLE 1. Spinal examination format described by Paris and Loubert<sup>26</sup>**

1. Pain assessment
2. Initial observation
3. History and interview
4. Structural inspection
5. Active movements
6. Neurovascular assessment
7. Palpation for condition
8. Palpation for position
9. Palpation for mobility
10. Upper- and/or lower-quarter assessment
11. Radiologic and other medical data
12. Summary of findings
13. Treatment plan
14. Explanation and prognosis

measuring pain<sup>27,28</sup>, 9 words were selected from 8 different categories. The words circled included stabbing, sharp, hurting, splitting, tiring, penetrating, piercing, squeezing, and nauseating. Paris<sup>29</sup> has suggested that 3–6 categories marked be considered normal, whereas  $\geq 8$  categories marked may indicate an abnormal emotional reaction that may hinder the patient's progress. Paris<sup>29</sup> also considered the selection of categories 11, 13, 14, and 16 as additional indicators of a strong emotional reaction to pain. Eight categories were selected, including category 11, identifying the patient as having a possible abnormal response to the pain. Data regarding the reliability and validity of this particular use of the MPQ were not discovered.

Average daily pain was rated as a 5 on a 0–10 NPRS. At its worst, the headache was rated as a 10 on the NPRS. The NPRS is simple to administer and has demonstrated good levels of reliability, validity, and responsiveness<sup>11,27,31-33</sup>. Childs et al<sup>31</sup> have reported a 2-point change on the NPRS as its minimal clinically important difference (MCID), albeit for patients with low back pain.

### *Initial Observation*

An initial observation was done when the patient was in the waiting area. A slightly endomorphic body type and medium height were observed, as was an overall kyphotic posture with a forward head posture when completing the insurance intake forms.

### *History and Interview*

The patient was a 43-year-old female who had injured her neck in an MVA 2 years earlier. At the time of the accident, the patient was driving when her vehicle was impacted on the driver's side by a semi truck. Neck pain and headaches

developed within minutes after the accident. A brief course of physical therapy was provided 2 weeks after the injury consisting of ultrasound, superficial heat, mechanical traction, and exercise. The patient was unsure of the frequency and duration of this treatment period, but she estimated having received a total of 8–10 visits over a period of 3 weeks. She reported temporary mild relief at the conclusion of this period of treatment but symptoms returned soon after. A gradual increase began for no apparent reason 5 months prior to the current course of treatment.

Reported limitations in activities included being able to sleep only 4–5 hours per night, having to leave work early and missing work, all because of pain, and difficulty performing routine household chores. The patient was employed at a local factory on an assembly line and continued to work. Work activities were repetitive and required her to look down for long periods. Periodic rotation of her head was required to see other aspects of the assembly line. Small parts were handled routinely during work activities. Specific limitations involved sustained looking down and turning her neck at work, difficulty with turning her head to back up the car or to change lanes, and reading. In addition, occasional concentration and memory lapses were described including forgetting items that needed to be purchased at the grocery store, difficulty remembering the details of conversations with friends, and difficulty comprehending information during attempts at reading.

The bilateral head and neck pain were described as vice-like. At times the patient also had knife-like temporal region headaches. The neck pain was constant, and headaches were present on a daily basis. Aggravating factors included activities requiring the patient to look down for long periods or to turn her head. The patient indicated no factors that provided relief. Pain behavior during a 24-hour period included stiffness and discomfort upon awakening in the morning, variable intensities by mid-day and late afternoon, depending on activity level, and increased intensity by the evening. Pain was at times present at night and might or might not be affected by changes in position.

During the most painful episodes, the back of the head became so sensitive that it was hard to place it on a pillow. Severe headaches were associated with nausea, blurred vision, and tinnitus in the right ear, and occasional vomiting. The patient denied quadrilateral sensory changes or changes in bladder and bowel control. She also denied having problems of loss of balance, falling, sensation changes on the face, visual disturbances, lightheadedness, or quadrilateral weakness. Although commonly considered indicative of cervical artery and cervical cord compromise, no data on the diagnostic utility of these history items were found. With regard to the patient's report of occipital allodynia, Kerry and Taylor<sup>25</sup> mentioned scalp tenderness as a symptom of internal carotid artery ischaemia, but hypersensitivity of the head and neck has also been described in patients with chronic

WAD<sup>17</sup>. However, absence of data on diagnostic utility and a patient report of intermittent rather than constant allodynia seemed to make this symptom less useful with regard to differential diagnosis.

The patient's medical history included hypertension, three caesarean sections, appendectomy, hysterectomy, right carpal tunnel release, left wrist and hand fracture, and a cyst removal from the right palm. The patient reported depression and she attributed this to the pain, but she also related it to the passing of her father during the past year. The patient reported smoking one pack of cigarettes per day. Medications the patient was currently taking included the antidepressant Bupropion, the anti-hypertensive Inderal, and the anti-inflammatory medication Methylprednisone. Kerry and Taylor<sup>25</sup> implicated hypertension and smoking as risk factors for atherosclerotic cervical artery dysfunction. Palmer et al<sup>34</sup> found a small but consistent relationship between smoking and regional neck pain limiting activity (prevalence ratio 1.5; 95% confidence interval (CI) 1.3–1.6); other researchers have established a dose-response relationship between smoking and musculoskeletal pain<sup>35</sup>. Depression has been noted as an independent risk factor for neck and back pain<sup>36</sup>.

### *Structural Inspection*

Structural inspection revealed a moderate forward head posture, a mild right mid-cervical and left upper-cervical sidebent position, hypertrophy of the right sternocleidomastoid muscle, and mildly increased lumbar lordosis and thoracic kyphosis. Cleland et al<sup>37</sup> reported 81% interrater agreement for identification of a forward head posture. Fedorak et al<sup>38</sup> reported fair mean intrarater reliability ( $\kappa=0.50$ ) and poor mean interrater reliability ( $\kappa=0.16$ ) for visual assessment of lordotic posture of the cervical and lumbar spine when using a 3-point rating scale (i.e., normal, increased, decreased).

### *Active Movements*

Active range of motion (AROM) established by way of visual estimation demonstrated a moderate decrease for cranio-cervical flexion and left sidebending. Regional cervical AROM was moderately limited for flexion, right sidebending, and left rotation. Left sidebending and right rotation were only mildly restricted. Table 2 provides AROM data. Sidebending AROM in both directions improved when the cervical musculature was placed on slack by even minimal passive shoulder girdle elevation. With a history suspect for vertebral artery compromise, at this time neck extension AROM was not assessed because of concerns of impinging the vertebral artery<sup>39,40</sup>.

Pool et al<sup>41</sup> reported 97% interrater agreement for visual detection of a cranio-cervical flexion AROM restriction. Youdas et al<sup>42</sup> reported poor to good interrater reliability for vi-

**TABLE 2. Active range of motion findings (in degrees)**

	Visit 1	Visit 2	Visit 3	Visit 4	Visit 10	Visit 11
Flexion	45	NT	NT	NT	Normal	Normal
Right sidebending	48	NT	NT	62	Normal	Normal
Left sidebending	60	NT	NT	68	67	67
Right rotation	71	NT	82	88	Normal	Normal
Left rotation	55	60	67	75	80	82

NT=Not tested

sual estimation of cervical AROM (Table 3). Weir<sup>43</sup> provided a formula to use these interrater reliability Intraclass Correlation Coefficients to calculate the standard error of measurement (SEM):  $SEM = SD \times \sqrt{1-ICC}$ . With this SEM, we then calculated the minimal detectable change for visual estimation of AROM measurements of the neck at a 95% confidence interval ( $MDC_{95}$ ) using the formula  $MDC_{95} = 1.96 \times \sqrt{2} \times SEM^{44,45}$ . If a change in a measurement exceeds the  $MDC_{95}$ , we can be 95% confident that a true change has in fact occurred. Table 3 also provides standard deviations (SD) for visual estimation of cervical AROM as established by Youdas et al<sup>41</sup> and the calculated SEM and  $MDC_{95}$  for the AROM measurements used for this patient. In light of the absence of data on intrarater reliability, which would have been more relevant to this case report with only one therapist taking all measurements, and with intrarater reliability generally better than interrater reliability findings, we have to assume that the  $MDC_{95}$ -values provided in Table 3 are likely higher than the true values. Despite limited reliability, visual estimation of cervical AROM remains a common method used in the assessment of patients with cervical spine problems<sup>42,46</sup>.

**TABLE 3. Reliability and responsiveness of visual estimation of cervical active range of motion tests**

	ICC	SD	SEM	$MDC_{95}$
Flexion	0.42	10	7.60	21.1
Left rotation	0.69	13	7.28	20.2
Right rotation	0.82	15	6.30	17.5
Left sidebending	0.63	9	5.49	15.2
Right sidebending	0.70	10	5.50	15.2

ICC=Intraclass correlation coefficient; SD=Standard deviation; SEM=Standard error of measurement;  $MDC_{95}$ =minimal detectable change at 95% confidence

## Neurovascular Assessment

As part of the normal screening examination—but all the more relevant with smoking implicated as a risk factor for hypertension and hypertension in turn implicated as a risk factor for (cervical) atherosclerotic disease, a cardiovascular screening was done: blood pressure was 134/90 (mmHg) and heart rate was 72 (BPM). The systolic value placed the patient in the high normal range and the diastolic value indicated mild hypertension as compared to an adult population not taking anti-hypertensive medication<sup>47</sup>.

The upper-extremity neurovascular examination included a sensory examination including light touch and pinprick, deep tendon reflexes, and muscle-strength testing. Sensation and reflex testing was normal and neck and shoulder strength was grossly 4 on a 0–5 scale. Wainner et al<sup>48</sup> reported low sensitivity for upper-extremity deep tendon reflex testing and strength testing with values ranging from 3–24% and 12–29%, respectively; however, specificity was excellent with values of 93–95% and 66–86%, respectively, when compared to a reference standard of radiculopathy established by way of needle electromyography and nerve conduction studies. Interrater reliability was substantial for upper-extremity reflex testing ( $\kappa=0.73$ ) and poor to substantial for upper-extremity strength ( $\kappa=0.23$ –0.69) and dermatomal sensation testing ( $\kappa=0.16$ –0.67)<sup>48</sup>. Using a 3-point rating scale, Jepsen et al<sup>49</sup> reported median interrater  $\kappa$ -values of 0.69 for sensitivity to light touch and 0.48 for sensitivity to pin prick. Jepsen et al<sup>50</sup> reported a sensitivity of 0.73, a specificity of 0.86, a positive predictive value of 0.93, and a negative predictive value of 0.90 for a combination of manual muscle tests, sensation tests (light touch, pain, vibration), and sensitivity of nerve trunks to mechanical pressure when compared to patient report of pain, strength deficits, or paraesthesiae, indicating the screening value of a multi-test neurovascular assessment as used in this case report.

The sustained extension-rotation test was used for testing vertebrobasilar system function (Figure 1). This test produced immediate-onset dizziness. However, nystagmus, diplopia, confusion, or slow responses to questions, dysphagia, sensation changes on the face, and other signs suggestive of vertebrobasilar insufficiency were not observed. We will discuss data on interpretation of test results and diagnostic utility of this test in the discussion section.

## Palpation for Condition and Position

Palpation for condition for this patient involved palpatory assessment of tissue tone, tenderness, and myofascial mobility. Assessment techniques included palpation of superficial connective tissue mobility, deeper palpation of myofascia, and direct palpation of the articular pillars and facets<sup>40,51</sup>. Gently positioning the fingertips on the skin and then pulling the skin in various directions while attempting to not



Fig. 1. Sustained extension-rotation test

palpate any deeper than the subcutaneous fascia allowed for assessment of superficial connective tissue mobility. Deep myofascial palpation involved increased levels of pressure in a perpendicular direction through layers of tissue; shearing in a direction parallel to each other allowed for assessment of the mobility of these deeper tissue layers<sup>51</sup>. Direct palpation of the articular pillars and facets was performed with the fingers extended and positioned in a posterior and medial direction. The fingers were then hooked slightly to gain better access to the facets<sup>40</sup>.

The palpatory examination with the patient supine was significant for increased tone in the posterior cervical myofascia and the right sternocleidomastoid muscle. The right sternocleidomastoid was limited throughout in a longitudinal direction, with the sternoclavicular aspect being the most restricted. The cervical paraspinals were restricted in motion with regard to surrounding tissues in both longitudinal and medial to lateral directions, with the greatest restrictions at C5-T2. The right more than the left levator scapulae also had decreased mobility at their mid and distal aspects. The suboccipital region was tender to palpation with the suboccipital muscles in a swollen, stiff, and guarded

state<sup>40</sup>. Thickening was palpated at bilateral articular pillars throughout the cervical spine. There were no positional abnormalities noted. Bertilson et al<sup>46</sup> reported moderate agreement for palpation for tenderness of the cervical muscles ( $\kappa=0.46$ ), and Metcalfe et al<sup>52</sup> found moderate interrater reliability for C1 positional palpation ( $\kappa=0.63$ ) but no data were found on the diagnostic utility of the other tests used during this part of the examination.

### Palpation for Mobility

The palpation for mobility section of the examination included both segmental stability and mobility tests. The alar ligament test<sup>40</sup> was negative when examined prior to testing passive mobility. Although data on diagnostic utility of this ligamentous stability test are not available, it is still an important part of the examination process because of the significance of the damage that may be discovered. Aspinall<sup>53</sup> recommended that even if testing is negative but other clinical signs are present, hypermobility should be suspected and precautions should be taken.

A 0–6 rating scale was used to assess passive mobility at the cervical spine (Table 4). Although upper cervical segmental dysfunction was suspected, considering the patient report of nausea, tinnitus, blurred vision, and occasional vomiting with severe headaches, the presence of risk factors for cervical artery dysfunction (smoking, hypertension), and the findings on the vertebrobasilar test as noted above, at the time of this initial evaluation segmental evaluation of this portion of the neck, was deferred due to the possible adverse effects of end-range movement assessment on cervical artery function. The mid-cervical facet joints were assessed with an anterior-superior glide or unilateral flexion technique: with the patient supine, the head was rolled in a combined side-bending and rotation away while the resultant anterior-superior glide was palpated at the contralateral facet (Figure 2)<sup>40</sup>. Passive motion at the C6-T4 segments was examined in sitting specifically for forward bending and rotation. The head was guided in the desired direction and motion was palpated

**TABLE 4. Segmental mobility rating scale: Plus and minus modifiers are used to signify greater or smaller abnormalities<sup>26</sup>**

Grade	Description	Criteria
0	Ankylosed	No detectable movement
1	Considerable hypomobility	Significant decrease in expected range and significant resistance to movement
2	Slight hypomobility	Slight decrease in mobility and resistance to movement
3	Normal	Expected movement
4	Slight hypermobility	Slight increase in expected mobility and less than normal resistance to movement
5	Considerable hypermobility	Significant increase in expected mobility, eventually restricted by periarticular structures
6	Unstable	Significant increase in expected mobility without restraint of periarticular structures

at the interspinous spaces (Figure 3)<sup>40</sup>. Table 5 shows the findings of palpation for mobility tests.

When using mainly dichotomous rating scales, intrarater reliability for cervical palpation for mobility tests has been shown to be generally moderate to high, whereas interrater reliability rarely exceeded poor to fair agreement<sup>54</sup>. However, the technique used here has never been formally examined for reliability; the 0–6 rating scale expanded with plus and minus modifiers as used here has been qualitatively examined in the lumbar spine showing reasonable to good intrarater but a total lack of interrater reliability<sup>55</sup>.

### Upper Quarter Assessment

A screening examination of the upper quarter included AROM of the temporomandibular joints, elbows, wrists, and hands, and sagittal and scapular plane shoulder AROM. This screening examination revealed a mild but diagnostically irrelevant decrease in AROM at the right shoulder for flexion



Fig. 2. Assessment of mid-cervical facet anterior-superior glide



Fig. 3. Assessment of upper thoracic rotation

and scapular plane abduction. The temporomandibular joint, elbows, wrists, and hands were cleared.

### Radiological and Other Medical Data

Prior to this period of physical therapy, the referring physician was concerned about a possible aneurysm as cause for the reported headache. However, this was ruled out with normal MRI and CT scans.

### Summary of Findings

A summary of findings or physical therapy diagnosis was made using terminology from the ICF or *International Classification of Functioning, Disability and Health* (Table 6)<sup>56</sup>.

At the level of impairments, the physical therapy diagnosis included:

- Decreased segmental joint mobility at bilateral C2-C3, right C3-C4, bilateral C5-C6, and T1-T4 joints
- Segmental hypermobility at bilateral C4-C5 joints
- Likely upper cervical segmental joint restriction for which examination was deferred due to potential cervical artery compromise
- Myofascial hypertonicity and restriction in the suboccipital muscles, C5-T2 paraspinal muscles, bilateral levator scapulae, and right sternocleidomastoid muscles
- Headache of probable cervicogenic nature but with unknown etiology; differential diagnostic options considered included tension-type headache, cervicogenic headache, and headache related to cervical artery compromise
- Forward head posture
- General decrease in shoulder and neck muscle strength
- Concentration and short-term memory loss

At the level of limitations in activities, the physical therapy diagnosis included the following difficulties:

- Turning the head when backing out the car or changing lanes
- Looking down at a book while reading
- Performing frequent neck movements during work, especially to the limits of available ROM
- Finding a comfortable position during sleep requiring frequent position changes

At the level of restrictions in participation, the patient reported the need for early departures from and decreased productivity at work.

The stage of the patient's condition was chronic<sup>40</sup>. Irritability was at a moderate level, as the pain rating increased to an 8 by the time the initial examination was concluded<sup>40</sup>. The

**TABLE 5. Palpation for mobility findings**

	Visit 1	Visit 3	Visit 5	Visit 6	Visit 7	Visit 8	Visit 9	Visit 11
C0-C1			FL 2-					
C1-C2			LSB 2- RSB 3 LROT 2- RROT 1+	LSB 2 LROT L 2- RROT 1+			ROT R 2-	LSB 2+ RSB 3 LROT L 2+ RROT 2
C2-C3	BASG 2-	BASG 2-			BASG 2			
C3-C4	LASG 3 RASG 2+							
C4-C5	BASG 4	BASG 4			BASG 4			
C5-C6	BASG 2	BASG 2						
C6-C7	FL 3 BROT 3							FL 3 BROT 3
C7-T1	FL 3 BROT 3							FL 3 BROT 3
T1-T2	FL 2 BROT 2							FL 3 BROT 3
T2-T3	FL 2 BROT 2					LROT L 2 RROT 2+		FL 2+ BROT 2+
T3-T4	FL 2 LROT 2- RROT 2					LROT L 2 RROT 2+		FL 2+ BROT 2+

BASG=bilateral anterior-superior glide; LASG=left anterior-superior glide; RASG=right anterior-superior glide; FL=flexion; BROT=bilateral rotation; LROT=left rotation; RROT=right rotation; LSB=left sidebending; RSB=right sidebending

**TABLE 6. Definitions of the dimensions of health state<sup>56</sup>**

Dimensions of health state	Definitions
Impairment	Any loss or abnormality of body structure or of a physiological or psychological function.
Activity	The nature and extent of functioning at the level of the person. Activities may be limited in nature, duration, or quality.
Participation	The nature and extent of a person's involvement in life situations in relation to impairments, activities, health conditions, and contextual factors. Participation may be restricted in nature, duration, or quality.

patient's personal goals for physical therapy included mild decreases in headache and neck pain, improved neck AROM, and the ability to tolerate reading for 20–30 minutes three to four evenings a week.

### *Treatment Plan*

The treatment plan to address the above impairments included education on the findings during this initial examination; a preparatory treatment of the neck and shoulder region by way of superficial heat, myofascial and non-thrust joint manipulation of restricted segments, and a home program of specific exercises; and re-evaluation of potential

vertebrobasilar symptoms with the aim of eventual evaluation and management of the likely upper cervical joint restrictions.

Long-term seemingly realistic treatment goals established in collaboration with the patient included the following:

- Improved neck AROM with at most mild limitations remaining
- Improved ability to function in work activities, household chores, reading, and driving with average pain levels decreased to at most 2–3 on a 0–10 NPRS
- Ability to sleep 6–8 hours per night

## Explanation and Prognosis

Explanation of examination findings, physical therapy diagnosis, and proposed treatment plan and cooperative goal-setting serve not only to obtain patient informed consent with regard to management of the complaints but also to increase patient compliance with the proposed management approach.

Various prospective cohort studies and reviews of such studies have identified demographic factors including female gender, older age (>60), and a low level of education and physical factors such as high initial neck pain, higher initial headache intensity, more severe initial disability, higher levels of somatization, sleep difficulties, and upper-extremity symptoms as prognostic factors for prolonged recovery from a whiplash injury<sup>57-60</sup>. In contrast, in a systematic review of prospective cohort studies, Scholten-Peeters et al<sup>61</sup> discounted older age, female gender, and high acute psychological response as relevant prognostic indicators; only high initial pain intensity remained as a strong adverse prognostic factor. For this patient, almost-immediate high pain intensity was the most relevant adverse prognostic indicator. The relevance of the patient being female, having sleep difficulties and relatively high levels of disability, and her initial MPQ score was less evident. However, the overall presentation with other independent risk factors for neck pain not directly modifiable with physical therapy (smoking, depression) resulted in setting somewhat guarded long-term treatment goals as noted above.

## Interventions

As noted above, the proposed treatment plan included education, modalities, myofascial manipulation, non-thrust joint manipulation, a home exercise program of specific exercises, and re-evaluation of vertebrobasilar symptoms with the aim of eventual evaluation and management of the likely upper

cervical joint restrictions. Sessions were scheduled at a frequency of two per week. Visit one concluded with brief instructions in postural alignment, including the possible role of the forward head position on the described symptoms. All treatment sessions started with superficial heat as a preparatory treatment for the specific manual therapy procedures. Table 7 describes the manual therapy content for all sessions.

## Vertebrobasilar and Upper Cervical Spine Evaluation

On visit 2, the sustained extension-rotation test produced increased pain at the neck and forehead. Dizziness occurred within a few seconds of achieving the test position. The patient reported a mild blurring of vision after the test and a headache with an intensity of 7 on the NPRS. On the third visit, the sustained extension-rotation test was positive for dizziness and increased pain at the neck, top of the head, and forehead. The dizziness was immediate and the therapist noted mild confusion when he had the patient answer questions during the test. Headache was rated as a 4 on the NPRS. On visit 5, the sustained extension-rotation test was negative. There were no complaints of dizziness, no visual disturbances, no confusion during questioning, no increases in pain, or other signs potentially indicative of cervical artery compromise.

With a negative vertebrobasilar system test, palpation for mobility examination of the upper cervical spine was deemed safe. Flexion of C0-C1 was tested with the patient in supine and with her neck in physiologic neutral by nodding the head forward along an axis through both external auditory canals. Passive cranio-cervical sidebending was tested by gently side bending the head about an antero-posterior axis at about the level of the upper lip (Figure 4)<sup>40</sup>. To assess C1-C2 rotation, the mid-cervical spine was side-bent to end range, and the head was rotated in the opposite direction

**TABLE 7. Summary of manual therapy interventions in the various sessions**

	1	2	3	4	5	6	7	8	9	10
Paravertebral Elongation		X	X	X	X	X	X	X	X	X
Inhibitory Distraction		X	X	X	X	X	X	X	X	X
Rotation of Frontal Bone on Occiput		X	X	X	X	X	X	X	X	X
Seated Bilateral Rotation T1-2, T2-3, T3-4		X	X	X	X	X				
Mobilization to Right Sternocleidomastoid			X	X	X	X	X	X	X	X
Mobilization to Upper Thoracic Myofascia			X	X	X	X	X	X	X	X
Lateral Telescoping				X	X	X	X	X	X	X
Left Craniovertebral Sidebend					X	X	X	X	X	X
Right Rotation C1-2						X	X	X	X	X
Facet Opposition Lock Seated; Right Facets T2-3, T3-4							X	X	X	X



along the line formed by the eyes (Figure 5)<sup>40</sup>. Fjellner et al<sup>62</sup> reported 62% interrater agreement ( $\kappa_w=0$ ) for the C0-C1 flexion test for range of motion and 64% ( $\kappa_w=0.01$ ) for end-feel assessment. Olson et al<sup>63</sup> reported  $\kappa$ -values ranging from -0.027 to 0.182 for interrater reliability of range of motion assessment with the crano-cervical sidebending test; intrarater reliability yielded  $\kappa$ -values ranging from -0.022 to 0.137. In the Olson et al study, a 0–6 rating scale was used similar to the one used in this case report. No data were located on the diagnostic utility of the C1-C2 segmental motion test used in this case report. Table 5 reports the segmental motion findings.

### *Myofascial Manipulation*

Myofascial manipulation techniques used included paravertebral elongation, which consists of gentle stroking from the upper trapezius to upper cervical regions with the patient

supine and starting at a superficial depth for a proposed autonomic effect and progressing to a moderate depth to affect mechanical changes (Figure 6)<sup>51</sup>.

Inhibitory distraction was used to decrease the observed suboccipital muscle tone (Figure 7)<sup>40</sup>. Briem et al<sup>64</sup> suggested that specifically chronic patients with headache might benefit from this particular technique.

Myofascial manipulation to the right sternocleidomastoid was performed with the patient supine with her head rotated left; it involved longitudinal stroking of this muscle from the mastoid process to its insertion on the clavicle and sternum<sup>51</sup>. Upper thoracic myofascial manipulation was performed with the patient supine and the therapist's hands positioned on myofascia along the lamina of the upper thoracic vertebrae stroking at moderate depth in a cranial-to-caudal direction (Figure 8)<sup>51</sup>.

Finally, the myofascial manipulation technique of lateral telescoping was added, whereby with one hand on the lateral pectoral area and the other on the thoracic area, the



*Fig. 4. Assessment of crano-cervical sidebending*



*Fig. 6. Paravertebral elongation*



*Fig. 5. Assessment of passive right rotation of C1-C2*



*Fig. 7. Inhibitory distraction*

therapist stretched laterally at a 45° angle with a moderate depth to assist with lengthening restrictive bilateral anterior and posterior thoracic soft tissue (Figure 9)<sup>51</sup>.

### *Non-Thrust Joint Manipulation*

As a trial treatment for the reported headache, rotation of the frontal bone on the occiput was used. For this technique, one hand stabilized the occiput with the other hand placed over the supra-orbital arches and frontal bone; the frontal bone was then “rotated” in both directions (Figure 10)<sup>29</sup>. Although controversial with regard to a possible mechanical effect as proposed within craniosacral therapy, this technique resulted in a decrease in the intensity of the reported headache when used and a noticeable relaxation effect on the facial musculature. This effect may have been related to decreases in facial spasms occurring with sustained pressure over the facial nerve<sup>65</sup>.

A segmental bilateral rotational grade III non-thrust manipulation was applied at T1–4. For left rotation, the technique was performed seated by having the patient turn to the left, stabilizing the lower member of the segment on the opposite side with a thumb on the spinous process, and gently pressing the superior spinous process with the other thumb to the right (Figure 11)<sup>29</sup>. A similar technique was performed to mobilize T1–4 right rotation.

As of the fifth visit, the atlas was mobilized with a left side-glide non-thrust manipulation technique. With the patient’s head cradled with the therapist’s left arm, a cranio-cervical left sidebending position was introduced, while the right hand gently pressed C1 to the left (Figure 12)<sup>40</sup>. As of the sixth visit, the C1-C2 segment was manipulated into right rotation because this direction presented with the greatest restriction: with the patient seated, the therapist’s right arm cradled the patient’s head and gently turned C1

and the head to the right while the left thumb blocked C2 on the side of the lamina (Figure 13)<sup>40</sup>.

A facet opposition lock technique was used on the right side at T2–4 in sitting: with the left thumb used as fulcrum on the spinous process of the inferior vertebra of the segment to be manipulated, the right hand moved the head forward and left until pressure was felt on the left thumb, at which point a gentle stretch was applied in that same diagonal direction (Figure 14)<sup>40</sup>.

### *Home Exercise Program*

On visit 4, a shoulder shrug exercise consisting of shoulder elevation combined with retraction was added with red Theraband-tubing to assist with the improvement of posture and to encourage extension in the upper thoracic spine. On this same visit, a gentle cervical sidebending stretch with a towel in both directions was added to maintain and improve any increases in motion gained during manual treatment. This stretch involved positioning one end of the towel under the armpit and the other end at the opposite lower cervical area. The sequence for the exercise was to partially side-bend toward the lower cervical towel end, pull both towel ends and hold them snug, then side-bend away until a stretch was felt and held for a few seconds twice a day for 5–10 repetitions (Figure 15).

To improve postural awareness and alignment, on visit 6 the patient was instructed to draw her head back into comfortable alignment by gently pushing on her chin and pulling her shoulders back while in front of a mirror. The patient was instructed to perform this positioning exercise 3–5 times per day.

With strength assessed at 4 on a 0–5 scale, an exercise to strengthen the interscapular muscles deemed important for maintaining correct posture was added to the home program



*Fig. 8. Mobilization of right sternocleidomastoid*



*Fig. 9. Lateral telescoping*



*Fig. 10. Rotation of frontal bone on occiput*



*Fig. 12. Mobilization of left cranio-cervical sidebending*



*Fig. 11. Left rotation mobilization T3-T4*



*Fig. 13. Mobilization of right rotation C1-C2*

on visit 8. In prone with the head and neck in physiologic neutral, the patient unilaterally horizontally abducted the arm at the shoulder holding a 1-lb weight in both hands.

Finally on visit 9, a self-resisted isometric exercise for the cervical muscles was added to the home program. The head was pressed into the hand forward, backward, and sideways to the right and left for five repetitions of ten seconds. Neutral head and neck posture was maintained during the isometric contraction, with the intent of recruiting the deep stabilizing muscles, including the deep cervical flexors. A sub-maximal contraction was used to avoid increasing stress on the hyper-mobile C4-C5 segment. Increasing the hyper-mobility was a concern because of the shear forces that could be produced, causing a mobilization effect at C4-C5 if the contraction was too strong<sup>66</sup>, but the primary author deemed this risk minimal.



*Fig. 14. Facet opposition lock technique seated for the right T3-T4 joint*

## Outcomes

Tables 2 and 5 provide data on AROM and palpation for mobility findings throughout the course of treatment. In as far as quantitative data on AROM were collected, pre- to post-treatment changes on left rotation exceeded the  $MDC_{95}$ , whereas changes on right rotation and right sidebending almost equaled the  $MDC_{95}$ , indicating that a true improvement had occurred for left rotation AROM and likely true improvements for right rotation and sidebending AROM. Examination on the final visit yielded minimal suboccipital myofascial abnormalities, but mild palpatory abnormalities remained longitudinally at the inferior right sternocleidomastoid and the distal attachments of the right and left levator scapulae. Strength at the neck and shoulder muscles was graded with manual muscle tests as 5 on a 0–5 scale. However, the cervical flexor muscles increased minimally to 4+ on a 0–5 scale.

Average neck pain ratings on the NPRS decreased from 5 at the initial examination to 1 at discharge. This change in average NPRS scores exceeded the MCID for this measure of



*Fig. 15. Towel stretch*

2, thereby indicating that a clinically meaningful reduction in average pain intensity had occurred<sup>31</sup>. Mild episodes of discomfort remained at the neck, especially after work activities. Headaches were present one to two times per week for an average of one hour, as compared to being almost constant when treatment started. The headache pain—when present—decreased from a 10 on the 0–10 NPRS to a 2–3 at discharge, again exceeding the MCID for this measure and indicating that a clinically meaningful reduction in headache intensity had occurred. The patient reported that these headaches no longer hindered her ability to function during a routine day.

With regard to limitations in activities and restrictions in participation, the patient noted greater ease at work and regular attendance, less difficulty performing household chores, less difficulty driving her car, and a return to previous reading activities. The patient was now sleeping through the night, rarely interrupted. Over all, she indicated she had a feeling of greater energy, improved ability to concentrate, and a more positive outlook during a routine day. The patient was discharged from physical therapy with the long-term treatment goals achieved.

## Discussion

This case report documents the diagnosis and management of a patient with chronic whiplash-related complaints. Management consisting of a multi-modal physical therapy program including education, myofascial and non-thrust joint

manipulation, specific exercise prescription, and modalities resulted in a favorable outcome with the patient showing true and clinically meaningful changes with regard to neck and headache pain intensity and cervical AROM. Although we recognize the major methodological limitation of this case report format in that it cannot establish a cause-and-effect relationship, we also propose that true and meaningful changes in a chronic condition despite the presence of various poor prognostic indicators not amenable to physical therapy intervention lend at least anecdotal support to the use of a mechanism-based approach to the management of patients with chronic whiplash syndrome. In the mechanism-based approach, the therapist assumes impairments identified on examination to be causally related to limitations in activities and restrictions in participation; these identified impairments then become the focus of intervention with the eventual goal of increasing patient function.

There are other limitations to this case report. Using more validated outcome measures related to disability as a result of impaired neck function and headache would have made a stronger case for establishing the presence of true and meaningful changes. In this regard, the Neck Disability Index and the Headache Disability Inventory would have been relevant outcome measures with data on reliability, validity, and responsiveness<sup>67-70</sup>. With regard to diagnosis, using a median nerve bias upper limb nerve tension test with its established high sensitivity (0.95; 95% CI: 0.90–1.0)<sup>48</sup> or even the full diagnostic test cluster established by Wainner et al<sup>48</sup> to more confidently exclude radicular involvement rather than relying on the neurovascular assessment with established low sensitivity would have allowed us to more confidently exclude radicular involvement in this patient. Using the International Headache Society diagnostic criteria<sup>71</sup> to more clearly distinguish between a possible tension-type or cervicogenic headache and examining the patient for myofascial trigger points that have been proposed to play a major etiologic role in tension-type headache<sup>72</sup> would likely have allowed for more specific and effective management. This is all the more relevant because cervicogenic and tension-type headache seem to respond differently to manual therapy interventions<sup>73,74</sup>. However, with a patient report of nausea, tinnitus, blurred vision, and occasional vomiting with severe headaches, the presence of risk factors for cervical artery dysfunction (smoking, hypertension), and the findings on the sustained extension-rotation test as noted above, the main emphasis when discussing lessons that might be learned from this case report involve the discussion and critical evaluation of clinical reasoning in the presence of diagnostic uncertainty with regard to cervical artery compromise.

It is a safe assumption to say that in all physical therapists a measure of vigilance—or perhaps even hypervigilance—is instilled during orthopaedic manual physical therapy courses in entry-level and post-graduate education with

regard to vertebrobasilar system compromise. Various history items and tests and even complete protocols have been proposed and developed with the intent of diagnosing this dysfunction<sup>75,76</sup>. However, there are a number of problems with these proposed diagnostic measures related to the construct and predictive validity of the proposed physical examination tests and even as to what constitutes positive history or physical examination findings indicative of cervical artery compromise.

In their course along the upper cervical spine, the vertebral arteries are tethered at the C1 and C2 transverse foramina and the atlanto-axial membrane. It is easy to imagine how rotation would have the potential to apply tensile forces to and thereby occlude the contralateral artery<sup>25</sup>. In 1927, De Kleyn and Nieuwenhuys<sup>77</sup> reported decreased or even absent vertebral artery blood flow based on cadaver perfusion studies in different head and neck positions. Based on these anatomical observations and these early perfusion studies, the sustained extension-rotation and the sustained rotation tests have been proposed and widely instructed and used as tests to determine the presence of vertebrobasilar artery dysfunction.

The sustained extension-rotation test has been extensively studied with equivocal results. Some authors have reported significant decreases in blood flow<sup>78,79</sup>, whereas other studies found no changes<sup>80,81</sup>. Case reports have noted false negative results<sup>82,83</sup>, and case series have reported 75–100% false positive results<sup>81,84</sup>. Côté et al<sup>85</sup> reported 0% sensitivity for detection of increased impedance to blood flow, 0% positive predictive value, and 63–97% negative predictive value. Research findings for the sustained cervical rotation test are equally equivocal with significant decreases<sup>78-80,86,87</sup> or no effect noted on vertebral artery blood flow or volume<sup>88,89</sup>.

The ICA provides 80% of blood flow to the brain versus 20% supplied by the vertebrobasilar system. Increased ICA flow compensates for decreased vertebrobasilar flow as may occur during the sustained (extension) rotation test<sup>25</sup>. With the ICA traversing various anterior cervical muscles (sternocleidomastoid, longus capitis, stylohyoid, omohyoid, and digastric muscles) and the artery being fixed to the anterior aspect of the C1 vertebral body and in the carotid canal in the petrous bone, blood flow through the ICA might be influenced by extension and contralateral rotation<sup>25,90,91</sup>. Based on these haemodynamic and anatomical considerations, the sustained rotation and extension-rotation tests have also been proposed as tests of ICA function.

Refshauge<sup>92</sup> noted an increase in right ICA blood flow velocity with sustained contralateral rotation in healthy volunteers. In contrast, Licht et al<sup>91</sup> found no change in peak flow or time-averaged mean flow velocity in the ICA during sustained extension-rotation test. It is relevant that the patients in that study nonetheless experienced symptoms (vertigo, visual blurring, nausea, hemicranial paraesthesiae) classically considered a positive response on this test. Rivett

et al<sup>78</sup> reported an increase in ICA blood flow velocity with cervical extension and attributed this to narrowing in the ICA. In contrast to the other two studies, they noted a decrease in peak systolic and end-diastolic blood flow velocity in both ICA during sustained rotation. Again relevant with regard to the clinical interpretation is the fact that these authors found no between-group differences for subjects that were positive or negative on this test.

With all these studies, we have to acknowledge the chance of type II error due to the small sample sizes used; for some studies, we must consider the effect of using asymptomatic subjects on external validity. In summary, research on the haemodynamic effect of the sustained rotation and the sustained extension rotation tests as used in this case report is equivocal, calling into question the construct validity of these tests as tests for cervical artery function.

Predictive validity of the above tests is especially relevant with the potential devastating effect of intervention-related adverse effects. Thiel and Rix<sup>92</sup> justifiably questioned how positional testing of haemodynamics in a still patent vessel could be expected to produce clinically useful information regarding the risk of injury with manipulative interventions. They also suggested that in case of an already pathologically weakened vessel wall, performing the test itself might put the patient at greater risk due to the potential stretching forces exerted; at least in cadaver studies, strain values produced during the test exceeded those produced with manipulation. It is conceivable that in the case of a vessel spasm or with embolization of a thrombus from an atherosclerotic vessel wall as cause for an adverse effect, the test itself might have been the cause for the ensuing pathology. The predictive validity of these tests is also challenged by Haldeman et al<sup>93</sup>; in their retrospective analysis of 64 medicolegal records describing cerebrovascular ischaemia after cervical spine manipulation, the clinicians involved described doing the sustained extension-rotation test in 27 cases with none of these patients having adverse responses.

Although relying on history items indicative of cervical artery pathology rather than on tests with seemingly poor validity and a potential for injury seems a clinically sound

**TABLE 8. Classic cardinal signs of vertebrobasilar compromise: Five D's And three N's<sup>25,94</sup>**

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Dizziness
Drop attacks
Diplopia (including amaurosis fugax and corneal reflex)
Dysarthria
Dysphagia (including hoarseness and hiccups)
Ataxia of gait
Nausea
Numbness (in ipsilateral face and/or contralateral body)
Nystagmus

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strategy, we have to also acknowledge that the diagnostic utility of the classic cardinal signs and symptoms (the 5D's And 3N's; Table 8) of vertebrobasilar compromise<sup>25,94</sup> has yet to be established. Hypervigilance for potential cervical artery compromise in combination with an overly narrow view of possible signs and symptoms focusing only on these classic cardinal signs can mislead the clinician and result in inappropriate diagnostic and management decisions.

Dissection is one underlying cause for cervical artery dysfunction. Arterial dissection involves tearing of the intimal wall with resultant ischaemic effects due to subsequent extension of the dissection along varying distances of the artery<sup>25,95</sup>. Cervical artery dissection is responsible for approximately 20% of all strokes in young patients versus 2.5% of strokes in older patients<sup>96</sup>. In patients under the age of 60, spontaneous ICA dissections account for 5–20% of strokes<sup>97</sup>. In the US, incidence of ICA dissection is estimated at 7,000 per year<sup>95</sup>.

Various risk factors might predispose patients to cervical artery dissection (Table 9)<sup>25,98</sup>. Mitchell<sup>99</sup> provided research support for the relevance of atherosclerotic changes: in a study of 362 cadaver vertebral arteries, she found the highest incidence of atherosclerosis in the atlanto-occipital portion of the vertebral arteries (42.0%). With blood flow proportional to the 4<sup>th</sup> power of the vessel diameter, this identifies patients with atherosclerosis as a population at risk for developing vertebrobasilar ischaemia. Rubinstein et al<sup>100</sup> reported migraine (OR=3.6), neck manipulation (OR=3.8), homocysteine levels (which may cause endothelial damage; OR=1.3), and a history of recent infection (OR=1.6) as risk factors for cervical artery dissection.

**TABLE 9. Proposed risk factors for cervical artery dissection<sup>25,98-100</sup>**

- 
- Atherosclerosis
  - Hypertension
  - Hypercholesterolaemia
  - Hyperlipidaemia
  - Hyperhomocysteinaemia
  - Diabetes mellitus
  - Genetic clotting disorders
  - Infections
  - Smoking
  - Free radicals
  - Direct vessel trauma due to extreme sustained or repeated neck movement, including whiplash and manual therapy interventions
  - Iatrogenic causes, e.g., surgery or medical intervention
  - Endothelial inflammatory disease, e.g., temporal arteriitis
  - Upper cervical instability
  - Arterioopathies, e.g., Marfan's syndrome, Ehlers-Danlos syndrome, and fibromuscular dysplasia
  - Migraine
-

With regard to raising the clinical suspicion of cervical artery dissection, it is important to realize that ischaemic symptoms are not the only symptoms that occur with cervical artery dissection. Non-ischaemic symptoms usually develop first and are likely the result of deformation of nerve endings in the tunica adventitia of the affected artery and direct compression on local somatic structures<sup>25</sup>. In fact, these non-ischaemic symptoms occur hours to days and even a few weeks prior to the ischaemic findings<sup>96</sup>. In the case of ICA dissection, this delay may even be as much as years<sup>95</sup>. Ischaemic findings develop in 30–80% of all dissections. Up to 20% of patients progress to a full cerebrovascular accident<sup>96</sup>. Non-ischaemic symptoms are unique to the pathology of dissection but ischaemic symptoms can, of course, be expected to be similar for all underlying causes of cervical artery dysfunction.

Although the classic cardinal signs and symptoms for vertebral artery compromise as discussed above (Table 8) can be part of the presentation, additional symptoms have been

described for cervical artery dysfunction. Table 10 provides ischaemic and non-ischaemic signs and symptoms associated with cervical artery dissection<sup>25,95-98,101,102</sup>. Relevant to the physical examination are the cranial nerve (CN) palsies that may occur with cervical artery dissection. Dissection of the ICA mainly causes CN IX-XII dysfunction with the hypoglossal nerve initially affected and then the other three nerves; eventually all cranial nerves except the olfactory can be affected<sup>25,96,100</sup>. Whereas cranial nerve dysfunction has a non-ischaemic etiology in ICA dissection, it is part of the ischaemic presentation of a vertebral artery dissection. As noted above, ischaemic signs and symptoms of cervical artery compromise can logically be expected to be similar irrespective of underlying pathology.

For the patient described in this case report, there were a number of signs and symptoms that raised the index of suspicion with regard to potential cervical artery compromise. First, there was the patient report of nausea, tinnitus, blurred vision, and occasional vomiting with severe head-

**Table 10. Non-ischaemic and ischaemic signs and symptoms of cervical artery dysfunction**<sup>25,95-98,101,102</sup>

	<b>Vertebrobasilar system</b>	<b>Internal carotid artery</b>
Non-ischaemic	<ul style="list-style-type: none"> <li>• Ipsilateral posterior neck pain</li> <li>• Ipsilateral occipital headache</li> <li>• Sudden onset and severe</li> <li>• Described as stabbing, pulsating, aching, “thunderclap,” sharp, or of an unusual character: “a headache unlike any experienced before”</li> <li>• Very rarely C5-C6 nerve root impairment (due to local neural ischaemia)</li> </ul>	<ul style="list-style-type: none"> <li>• Ipsilateral upper and mid-cervical spine pain</li> <li>• Ipsilateral frontal-temporal or peri-orbital headache</li> <li>• Sudden onset, severe, and of an uncommon character</li> <li>• Horner’s syndrome</li> <li>• Pulsatile tinnitus</li> <li>• Cranial nerve palsies</li> <li>• Ipsilateral carotid bruit</li> <li>• Neck swelling</li> <li>• Scalp tenderness</li> <li>• Anhydrosis face</li> </ul>
Ischaemic	<ul style="list-style-type: none"> <li>• Five D’s And three N’s (see Table 8)</li> <li>• Vomiting</li> <li>• Loss of short-term memory</li> <li>• Vagueness</li> <li>• Hypotonia and limb weakness affecting arm or leg</li> <li>• Anhydrosis: lack of facial sweating</li> <li>• Hearing disturbances</li> <li>• Malaise</li> <li>• Perioral dysaesthesia</li> <li>• Photophobia</li> <li>• Clumsiness</li> <li>• Agitation</li> <li>• Cranial nerve palsies</li> <li>• Hindbrain stroke: Wallenberg or locked-in syndrome</li> </ul>	<ul style="list-style-type: none"> <li>• Transient ischaemic attack</li> <li>• Middle cerebral artery distribution stroke</li> <li>• Retinal infarction</li> <li>• Amaurosis fugax: temporary blindness</li> <li>• Localized patchy blurring of vision: scintillating scotomata</li> <li>• Weakness extra-ocular muscles</li> <li>• Protrusion of the eye</li> <li>• Swelling of the eye or conjunctiva</li> </ul>

aches. Second, there was the presence of known risk factors for cervical artery dysfunction, i.e., smoking and hypertension. Finally there were the findings on the sustained extension-rotation test: immediate-onset dizziness or dizziness with a very short latency period, mild confusion, and headache and neck pain.

Relating the above information to the patient described in this case report, it becomes clear that the patient-reported symptoms are not likely to reflect an ischaemic or non-ischaemic presentation of cervical artery dysfunction (Table 10). The risk factors remain relevant, but with a lowered pretest probability and in the absence of data on diagnostic utility they have less of a diagnostic impact. Finally, the symptoms reported on the sustained extension-rotation test are likely indicative of pathology other than cervical artery dysfunction. Especially relevant is the immediate onset or short latency of the dizziness with the test: immediate-onset dizziness has been described for cervicogenic dizziness and dizziness with a short latency has been described for peripheral vestibular dysfunction, more specifically benign paroxysmal positional vertigo (BPPV)<sup>103</sup>. Relevant to this case report is that both pathologies have been reported as the sequelae of an MVA. Cervicogenic dizziness and BPPV have been described as producing positioning-type dizziness rather than positional dizziness in that they occur with short or no latency with the change in position rather than with sustaining the position and that they accommodate, both when holding the position and with repeated testing<sup>104</sup>. In contrast, cervical artery compromise would be expected to

produce a positional dizziness that had a slow onset, was progressive when held in the test position, and did not accommodate to repeated testing: position-dependent ischaemia produces symptoms when sufficient vascular deprivation of neural and other structures is achieved with progressive symptoms as ischaemia is maintained<sup>103,105</sup>. In fact, Oostendorp<sup>105</sup> reported a latency period of  $55 \pm 18$  seconds after assuming the sustained extension-rotation test position for patients with a clinical suspicion of vertebrobasilar ischaemia. Table 11 provides information helpful in the differential diagnosis of cervical artery dysfunction, cervicogenic dizziness, and BPPV. Reviewing Table 11, it becomes evident that the symptoms produced with the sustained extension-rotation test were consistent with cervicogenic dizziness rather than BPPV or cervical artery dysfunction.

## Conclusion

This case report provides support for the use of a mechanism-based multi-modal physical therapy approach including education, myofascial and non-thrust joint manipulation, specific exercise prescription, and modalities for the treatment of patients with chronic whiplash-related complaints. More importantly, this report provides a critical discussion of construct and predictive validity of the sustained rotation and rotation-extension tests and of risk factors and signs and symptoms indicative of cervical artery dysfunction. Although

**TABLE 11. Differential diagnostic characteristics for cervicogenic dizziness, benign paroxysmal positional vertigo (BPPV), and cervical artery dysfunction (adapted with permission from Huijbregts and Vidal<sup>103</sup>)**

	Dizziness type	Nystagmus and dizziness characteristics	Associated signs and symptoms
Cervicogenic dizziness	Positioning-type	<ul style="list-style-type: none"> <li>No latency period</li> <li>Brief duration</li> <li>Fatigable with repeated motion</li> </ul>	<ul style="list-style-type: none"> <li>Nystagmus</li> <li>Neck pain</li> <li>Suboccipital headaches</li> <li>Cervical motion abnormality on examination</li> </ul>
BPPV	Positioning-type	<ul style="list-style-type: none"> <li>Short latency: 1-5 seconds</li> <li>Brief duration: &lt;30 seconds</li> <li>Fatigable with repeated motion</li> </ul>	<ul style="list-style-type: none"> <li>Nystagmus</li> </ul>
Cervical artery dysfunction	Positional-type	<ul style="list-style-type: none"> <li>Long latency: 55+/-18 seconds</li> <li>Increasing symptoms and signs with maintained head position</li> <li>Not fatigable with repeated motion</li> </ul>	<ul style="list-style-type: none"> <li>Ischaemic and (depending on etiology) possibly non-ischaemic signs and symptoms as described in Table 10</li> </ul>



continued research into the diagnostic utility of risk factors, history items, and physical tests related to cervical artery dysfunction is clearly needed, this critical review of current best evidence should also serve to decrease the current hypervigilance among physical therapists with regard to cervical artery compromise, thus ensuring the most appropriate diagnosis and management decisions for their patients.

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