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The application of a pre-positioned upper cervical traction mobilization to patients with painful active cervical rotation impairment: A case series

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Abstract.
BACKGROUND: Cervical mobilization and manipulation have been shown to improve cervical range of motion and pain. Cervical rotatory thrust manipulation has been associated with adverse patient reaction and damage to the V3 segment of the vertebral artery (VA).
OBJECTIVE: To document and describe the effects of an upper cervical (UC) traction based mobilization on participants with restricted and painful cervical rotation and to document if the mobilization changed blood flow velocity through the vertebral artery.
METHODS: This case series examined the effects of a traction based spinal mobilization on two different groups of participants. Group I included 93 participants with restricted bilateral cervical rotation that was also painful at end range. Group II included 30 different participants whose VA blood flow velocity was examined during the same mobilization. Pre- and post-mobilization active cervical rotation, pain intensity levels, and VA blood flow velocity during mobilization was documented.
RESULTS: Paired T-tests were used to determine statistical significance for changes in cervical rotation, and VA blood flow velocity during mobilization. Ninety-three participants in group I demonstrated an average increase of 16 degrees of cervical rotation. No participant demonstrated an increase in pain, and no participant in group II ($N = 30$) demonstrated a change in VA blood flow velocity.
CONCLUSIONS: The application this UC traction based mobilization improved active cervical rotation, end range rotation pain response, did not cause pain during its application and did not alter blood flow through the VA during application.

Keywords: Cervical mobilization, cervical manipulation, vertebral artery

1. Introduction

1.1. Background and objectives

It is estimated that 10.2 million Americans are seen annually for neck pain in outpatient ambulatory care clinics [1]. Thrust manipulation and non-thrust mobilizations applied to the cervical spine are considered two different forms of conservative manual intervention for neck pain. The literature has shown that these two interventions have demonstrated positive effects for pain, motion impairments and outcome assessments [2–5].

Cervical thrust manipulation involves the applica-

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tion of a high-velocity passive motion. Often, the passive motion is rotational in nature. Some cervical thrust manipulations use the patient's head as a manual contact point to deliver a rotatory motion through the upper cervical (UC) and lower cervical (LC) segments. When performed in that way thrust manipulation is not without controversy. Di Fabio [6] performed a literature review on cases and case reports involving injury following manipulation of the cervical spine from 1966 to 1997. The results revealed arterial dissection, lesions of the brain stem, and Wallenberg syndrome as the most frequently reported cases and the majority of injuries were attributed to manipulation by clinicians using manual techniques with a component of rotational thrust. These rotational thrusts may have an adverse effect on the V3 segment of the vertebral artery (VA). The V3 segment exits the transverse foramen of C2, courses between the C2 and C1 vertebrae, and enters the transverse foramen of C1. This is felt to be the most common area of vertebral artery injury during cervical manipulation [7,8]. In addition, the V3 segment has a significantly increased incidence of atherosclerotic plaque formation based on human cadaver research [9].

Several case reports have been published in the literature describing adverse effects related to the V3 segment following cervical thrust manipulation. Parenti et al. [10] described a case report of a 50-year-old woman who underwent manipulative treatment involving head rotation for upper neck pain. The woman reported adverse effects such as headache, dizziness, nausea, vomiting and facial numbness within a few minutes following treatment. A subsequent MRI revealed a recent left vertebral artery occlusive dissection and ipsilateral internal carotid artery dissection. Devereaux [11] described a case report of a 34-year-old woman with right visual field disturbances following three chiropractic treatments. Post treatment, magnetic resonance angiography revealed a right vertebral artery dissection at the C1 level. Unfortunately, an exact description of the manipulative technique was not described. In addition, Preul et al. [12] described a case report of a 33-year-old woman who underwent a manipulative maneuver involving rotation and began having tonic-clonic seizures the next day. Again, magnetic resonance angiography showed bilateral vertebral artery dissection at the V3 segment.

In light of the concerns related to the use of cervical rotatory thrust manipulation, and its possible association with injury to the V3 segment of the VA the researchers sought to explain an alternative UC mobilization which incorporates rotational pre-positioning of the UC region, but uses a traction force to achieve additional UC soft tissue stretching after the majority of UC soft tissue slack is taken up with rotational pre-positioning. We sought to examine whether this traction based mobilization improved cervical rotation and whether it did so without provoking discomfort during and immediately after its application. We also sought to examine whether a traction based UC mobilization caused any significant alteration in VA blood flow.

2. Methods

2.1. Participants

Following receipt of Intuitional Review Board approval participants with limited and painful cervical rotation were identified. Participants were included if their active range of neck rotation was less than 80° in both directions when examined with the cervical range of motion device (CROM) [13–15] and if their verbal pain response was greater than two on the numeric pain rating scale (NPRS). Participants were screened for and excluded if they presented with any absolute contraindication to spinal mobilization such as acute fracture, dislocations, ligamentous rupture, instability, infection, tumors, acute myelopathy, acute soft tissue injury, osteoporosis, ankylosing spondylitis, rheumatoid arthritis, vascular disease, vertebral artery abnormalities, connective tissue disease and anticoagulant therapy [16,17]. A total of 93 participants, 60 females and 33 males, with a mean age of 57 years, were recruited into the range of motion (ROM) group.

Once identified, participants were supplied with written and oral information about the case series. If there were no questions, and the participant agreed, a written informed consent was signed. To ensure consistent data collection and technique application, the same clinician performed all measurements and mobilizations. Confidentiality was maintained through the use of number codes for each participant's data.

The same clinician also collected blood flow velocity data on a different group of 30 individuals (21 female; 36.6 years old; range 21–57 years) while applying the same UC traction mobilization technique for a period of 30 seconds [18]. Peak systolic velocity (PSV) and end diastolic velocity (EDV) were measured on all 30 participants in the blood flow group with his/her cervical spine in neutral (mid-line) and during the performance of UC pre-positioned traction mobilization. All Duplex Doppler ultra-sound (US) data was collected by the same ultrasonographer using a duplex Doppler ultrasound machine with color flow imaging (Phillips HDI 5000) and a 7.4 mHz linear array transducer [19]. Doppler US has demonstrated 90% sensitivity, 100% specificity, 100% positive predictive value and 95% negative predictive value for detection of disease at any point in the vertebrobasilar circulation [20]. Color coding was added during the investigation for all 30 participants as this allows for better visualization of blood flow in the vertebral artery [21].

Fig. 1. Manual stabilization of the C2 vertebra.

Fig. 2. Patient positioned in upper cervical coupled rotation.

2.2. Outcomes

The variables measured in this series included: active left and right cervical rotation measured immediately before and after the application of the mobilization technique, cervical pain intensity level using the 0–10 NPRS during the application of the mobilization technique, cervical pain intensity at end range cervical rotation both before and after technique application and VA blood flow velocity measured with the cervical spine in neutral and during the UC traction mobilization. Active range of motion (AROM) was measured using the CROM. The CROM has been found to have excellent reliability with an intra-class correlation coefficient of 0.95 for left rotation and 0.92 for right rotation [15]. The standard error of measurement for the CROM is 1.6–2.8°. The values for the minimal detectable change (MDC) ranged from 3.6–6.5° [17]. The NPRS has a moderate reliability with an ICC of 0.76 [22] and was measured during the first and third 10-second application of the mobilization technique for each of the 93 participants in the ROM group. Each participant was asked to report if he or she experienced any discomfort or unpleasant sensation during, between, or after any of these three 10-second applications. After CROM and NPRS values were attained for both left and right rotation, the participant's involvement in the series was completed.

2.3. Interventions

This series evaluated the effect of an UC traction mobilization technique on 93 participants with painful and restricted active cervical rotation, and examined blood in a separate group of 30 participants. UC traction mobilization incorporates a cranially directed translatory (traction) motion after pre-positioning the C0/C1 and C1/C2 segments in passive coupled UC rotation [23]. In terms of technique application, the clinician first manually stabilizes the C2 vertebra in mid-line with a bilateral laminar contact (Fig. 1). By virtue of the manual contact, the C2 vertebra is not allowed to rotate out of mid-position as UC soft tissue (capsular) slack is taken up with a combination of passive UC side bending and rotation in opposite directions. The passive rotational positioning of the UC segments in coupled rotation is accomplished by a manual contact on the top of the participant's head (Fig. 2). The two upper cervical motion segments are slowly positioned which allows the participant (patient) to inform the clinician whether any discomfort is experienced. Second, the ipsilateral side of the participant's head is contacted by the clinician's chest and the contralateral side of the participant's head (occipital region) is contacted by the clinician's mobilizing hand (Fig. 3). Third, the clinician straightens his or her knees and, at the same time, lifts in a cranial direction with his or her mobilizing hand and chest (Fig. 4). The stabilizing hand maintains a bilateral laminar contact and presses in a caudal and slightly ventral direction which assists in isolating the traction (stretching) force to the UC soft tissue structures. In this portion of the case series all 93 participants received three consecutive 10-second grade III tractions to their UC segments [24,25]. Participants were asked to rate their cervical pain on the 0–10 NPRS during the first and third 10-second applications [22].

Table 1
Within group comparison of active cervical rotation using a paired samples t-test, $N = 93$

	Pre-treatment mean	Post-treatment mean	Mean difference	P-values
Left rotation (°)	54.26°	62.04°	7.78°	$p < 0.000$*
Right rotation (°)	54.06°	61.98°	7.92°	$p < 0.000$*

*= statistically significant.

Fig. 3. Manual contact point for mobilizing hand.

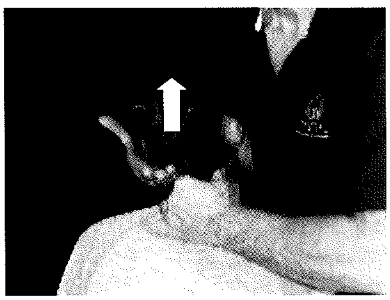

Fig. 4. Clinical application of Pre-positioned traction mobilization.

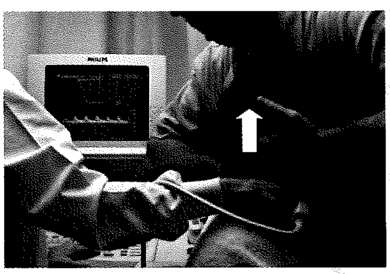

Fig. 5. Vertebral artery blood flow examination during pre-positioned traction mobilization.

In a separate portion of this series, 30 different participants received the same mobilization technique while a single measurement of VA PSV and EDV was taken with the participant's cervical spine in neutral and then taken again during UC traction mobilization. To promote hemodynamic stability, all 30 participants rested in a seated position for five minutes prior to measuring blood flow velocity [26]. With the participant in a seated position, the ultrasonographer placed the ultrasound transducer such that the VA was visualized as it entered the C6 transverse foramen [27]. PSV and EDV were then measured with the cervical spine in neutral. Next, the UC segments were positioned as described above and the UC traction mobilization was performed at Grade III intensity [24,25]. The left VA flow velocity was examined with the participants UC region placed in left coupled (Fig. 5) rotation and the right VA was examined in right coupled UC rotation. The mobilization was held for 30 seconds so the ultrasonographer could make and record the blood flow velocities. Blood flow data collection was performed with the participants in a seated position similar to the clinical application of UC traction mobilization. All 30 participants in the blood flow group were instructed to inform the researcher of any cervical discomfort, dizziness, or other unpleasant sensations experienced during the measurement of VA blood flow velocity. Similar to the ROM group, no participant reported any discomfort or unpleasant sensations.

2.4. Data analysis

The descriptive statistics calculated included mean values for cervical rotation pre and post mobilization for all 93 participants- male and female participants, participants over and under age 50 (Tables 1–3). A paired samples t-test was used to determine statistical significance and the P value was set at $p = 0.05$. The same data analysis was used to determine mean values for VA PSV and EDV (Table 4). The P value was set at $p = 0.05$ and was used to compare blood flow velocity with the cervical spine in neutral and during the UC traction mobilization.

3. Results

The means and P values for active cervical rotation prior to and immediately after the application of the mobilization technique can be seen in Table 1. All participants demonstrated an immediate eight-degree improvement in active cervical rotation in both directions yielding a total improvement of 16 degrees of active cervical rotation. Two additional ROM Tables 2 and

Table 2
Gender group comparison using a paired samples t-test before and after application of traction mobilization for left rotation and right rotation

		Pre-treatment mean	Post-treatment mean	Mean difference	P-values
Male	L rotation (°)	50.03°	57.42°	7.39°	$p = 0.353$
	R rotation (°)	50.88°	58.18°	7.30°	$p = 0.086$
Females	L rotation (°)	56.58°	64.58°	8.00°	
	R rotation (°)	55.82°	64.07°	8.25°	

L = left; R = right.

Table 3
Age group comparison using a paired samples t-test before and after application of traction mobilization for left rotation and right rotation

		Pre-treatment mean	Post-treatment mean	Mean difference	P values
Under 50 y.o.	Left rotation (°)	50.03°	57.42°	7.39°	$p = 0.728$
	Right rotation (°)	50.88°	58.18°	7.30°	$p = 0.476$
Over 50 y.o.	Left rotation (°)	56.58°	64.58°	8.00°	
	Right rotation (°)	55.82°	64.07°	8.25°	

y.o. = Years old.

Table 4
VA blood flow velocity (cm/s) and P values with cervical spine in neutral position and during pre-positioned UC traction mobilization

	Mean (cm/s)		Mean (cm/s)	P-values
PS neutral left VA	64	PS UC traction left VA	65	$p = 0.635$
PS neutral right VA	61	PS UC traction right VA	62	$p = 0.464$
ED neutral left VA	16	ED UC traction left VA	16	$p = 0.767$
ED neutral right VA	16	ED UC traction right VA	15	$p = 0.582$

Note: VA = vertebral artery; PS = peak systolic; ED = end diastolic; UC traction right = upper cervical traction mobilization performed in coupled right rotation; UC traction left = upper cervical traction mobilization performed in coupled left rotation.

3) are provided and demonstrate a similar increase in active cervical rotation for both male and female participants, and participants over and under the age of 50 years. NPRS data was collected during the first and third 10-second application of the UC traction mobilization. All 93 participants reported a zero on the 0–10 NPRS and no participant reported any other adverse reaction during the mobilization or while post-technique CROM measurements were being taken (Table 1). The NPRS findings for pain at end range active cervical rotation for group I (93 participants) improved (decreased) by 1.5. The means for VA blood flow velocity in cm/s for group II can be seen in Table 4. These mean blood flow velocity values are similar to other reported reference values [28,29]. Most importantly, the flow velocities showed little to no change during the application of this UC traction mobilization. The P values did not show statistical significance in terms of change in VA flow velocity during the mobilization as compared to when the participant's cervical spine was in neutral position (Table 4). Bendick and Glover [30] have noted that pathological occlusion of the VA would demonstrate a peak systolic blood flow velocity less than 10 cm/s. Our average value for peak systolic flow during the application of the UC traction mobilization remained over 60 cm/s.

4. Discussion

The purpose of this series was to determine if this UC traction mobilization caused immediate improvement in active cervical rotation, improvement in end range rotation pain response, and whether the technique could be performed without provoking even minor discomfort. A secondary purpose was to present VA flow velocity data during the performance of the same mobilization technique. Given the location of the ultrasound equipment, this was performed on a different group of participants. The results demonstrate statistically significant improvement in active cervical rotation, less pain at end range rotation, no pain response during the application of the mobilization and no change in VA blood flow (group II). The findings in Table 1 show that the 93 participants in this series showed a 7.78° improvement for left cervical rotation and a 7.92° improvement for right rotation. Both males and females had similar amounts of motion improvement (Table 2), with females demonstrating slightly greater mean improvement. Participants over and less than 50 years of age also had similar mean motion improvement with those over age 50 showing a slightly greater increase in range (Table 3). The researchers believe that this mobilization technique consistently improved rotational range of movement in all participants for the following reason. After manually stabilizing the C2 vertebra so that no rotational movement could occur in the lower cervical segments (Fig. 1), available UC rotational soft tissue slack is taken up using a combination of side bending and rotation in opposite directions (coupled rotation) [24]. At that point, a traction force (tensile load) is delivered to elongate any shortened UC connective tissues [31].

Adverse reaction to cervical rotatory manipulation can occur in both the UC and LC regions [32–35]. The researchers feel that slow and careful pre-positioning of the two upper cervical segments in coupled rotation allows a patient to inform the clinician if discomfort or any other abnormal or unpleasant sensation is felt. In addition, delivering a cranially directed manual traction motion as compared to manipulative techniques that deliver additional passive rotation at the end of a restricted rotational movement might contribute to all participants reporting a zero on the 0–10 NPRS during technique application. Lastly, the maintenance of the lower cervical segments in a neutral or mid-position with respect to rotation likely minimizes the chance of adverse reaction occurring in any of the LC segments [36].

Injury to the V3 segment of the VA may be related to and a potential result of thrust rotatory cervical manipulation. The means and P values shown in Table 4 for VA flow velocity indicate that this traction mobilization did not cause a statistically significant change in VA blood flow velocity or flow pattern [30,37]. The researchers feel that there are two principal mechanisms that reduce the load on the V3 segment of the VA. First, the UC segments are passively side bent and rotated in opposite directions. The simultaneous incorporation of both passive side bending and rotation will minimize the total amount of rotation placed through the UC segments as compared to rotation in the transverse plane alone. One could speculate that less total rotation between the C1 and C2 vertebrae may reduce the tensile and compressive loading on the V3 segment of the VA at its transverse process exit point out of the C2 vertebra and at its entrance point into the transverse process of the C1 vertebra (Fig. 3) [23].

Second, after UC soft tissue slack is taken up using coupled rotation the final treatment or stretching motion is a cranially directed manual traction. The researchers speculate that this traction movement does not create additional bending trauma to the V3 segment of the artery at its transverse process exit and entrance point. This is particularly important given the high incidence of atherosclerotic plaque formation affecting the V3 segment of the artery [9]. Cagnie et al. [9] noted that the stretching and compressive effects of rotational manipulation may impose additional risk for vertbrobasilar insufficiency.

5. Conclusion

The traction based UC mobilization technique applied to the C0/C1 and the C1/C2 segments improved active cervical rotation bilaterally in both males and females and in older and younger participants. The same mobilization technique was applied to 93 participants in one group and 30 participants in another group without any increase in cervical discomfort. In addition, this mobilization technique can be applied without significant change in VA blood flow velocity or blood flow pattern. Given this, it is unlikely that the V3 segment VA is being overly compressed or stretched as significant changes in arterial lumen diameter would create changes in blood flow velocity and wave pattern during Duplex Doppler examination. Given the low velocity nature of this technique, careful pre-positioning of the UC segments, and a final treatment direction which is cranial or traction based, this mobilization would appear to offer clinicians an additional means to address cervical rotation impairment which may be safer for the V3 segment of the VA as compared to rotatory thrust manipulation.

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Conflict of interest

None to report.

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