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ORIGINAL RESEARCH ARTICLE

Head Pain Reproduction and Resolution Behavior in Response to Sustained Mobilization of the Upper Cervical Spine: A Case Series

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ABSTRACT

Background: Reproduction and resolution of head pain with sustained upper cervical mobilization has been proposed as a diagnostic indicator of Cervicogenic Headache (CGH). However, there has been little focus on describing head pain response during the application of these maneuvers. The purpose of this study was to describe the head pain response during the performance of sustained upper cervical spine mobilization in people with probable CGH.

Methods: In this case series of 20 individuals with probable CGH as defined under the International Headache Society criteria, were assessed by one experienced physiotherapist who administered five sustained upper cervical spine mobilization techniques to each participant. Reproduction of head pain during mobilization was noted. At the start, during, and end of each mobilization technique, change in head pain intensity and time taken to achieve head pain resolution was recorded.

Results: Sixteen of the 20 participants experienced reproduction and resolution of head pain within 90 seconds of sustained upper cervical mobilization. This phenomenon occurred no more frequently with the mobilization of C2 than with C1. Eight patients reported this on the dominant head pain side only, 6 patients experienced this bilaterally. Neck pain was present in 13 of the 20 participants.

Conclusion: From this case series, it seems that neither the duration (measured in seconds) nor the magnitude of reduction in head pain intensity was markedly different across dominant compared to non-dominant head pain sides or across cervical levels, indicating reproduction and resolution behavior is irregular. The presence of CGH without neck pain is possible.

Keywords: Headache, Cervical Spine, Manual Examination, Sustained Joint Mobilization

What is already known about this topic?

- *Reproduction and resolution of head pain with sustained cervical spine mobilization have been suggested as an effective strategy for the diagnosis and management of CGHs.*

What does this study add?

- *This case series provides a complete documented description of the response to sustained cervical spine mobilization in a CGH population in terms of occurrence, intensity, spread, and resolution of head pain.*

Introduction

Cervicogenic Headache (CGH) is characterized by referred head pain from musculoskeletal dysfunction in the upper three cervical segments (1). Convergence of the trigeminal nerve complex with the upper cervical spinal nerve complex in the Trigeminocervical Nucleus (TCN) is thought to be the cause of referred pain to the head region (2). Approximately 15 to 20% of chronic and recurrent headache sufferers experience head pain from a cervicogenic origin (3).

Local cervical pain or reproduction of headache symptoms with upper cervical spine palpation is considered a key component necessary to determine if a headache is of cervical origin (4,5). Whilst physical findings indicating patterns of cervical musculoskeletal impairment including postural variances,(6) active range of movement limitations (7), and muscular impairments (8) have been associated with CGH, the presence of painful joints in the upper three cervical spinal levels as detected with manual examination is the physical examination finding that most clearly distinguishes CGH from other headache disorders (9).

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Reproduction and resolution of head pain with sustained upper cervical joint mobilization achieved by maintaining thumb pressure to passively stress a particular intervertebral segment has been proposed to be an important diagnostic indicator of CGH (10). Recent work has demonstrated that reproduction and resolution of head pain with sustained upper cervical joint mobilization can distinguish people with CGH from asymptomatic individuals with a sensitivity of 78% and specificity of 90% (11).

Head pain referral from the upper cervical spine occurs due to the convergence of cervical and trigeminal afferents in the TCN where nociceptive afferents from the C1 to C3 spinal nerves converge with second-order neurons which also receive afferents from the first division of the trigeminal nerve (2). Hyperexcitability of nociceptive second order neurons in the TCN may result from dysfunction in deep somatic tissues of the upper cervical spine (12) resulting in increased sensitivity to afferent information from the trigeminal field which is perceived as pain (13). Sustaining a passive mobilization maneuver, whereby head pain is reproduced and then lessens in intensity or resolves within 90 seconds, is suggested to cause a modulation in hyperexcitability of the second-order neurons of the TCN and diminution of pre-existing central sensitization (10,13-15).

The reduction of head pain following mobilization of the upper cervical spine has been previously described. Malo-Urries et al investigated the effect of translational mobilization in individuals with CGH reporting immediate improvements in pain intensity, range of movement, and pain pressure threshold (16). The mechanism proposed for this change is the mechanical stimulus of the mobilization technique could activate the descending pain inhibitory systems via corticospinal projections from the periaqueductal grey matter causing immediate hypoalgesic effects (16,17). However, these techniques used oscillatory techniques. Further effects have been hypothesized relating to the application of sustained end-range mobilization techniques including the reduction in the effects of reflex muscle contraction on periarticular and capsular structures with subsequent reduction in peripheral afferent discharge due to mechanical adaptation of encapsulated endings of joint nerves, and reduction in intraarticular pressure resulting in reduced peripheral afferent discharge and thereby decreased pain perception (18).

There is emerging evidence of the existence and usefulness of the reproduction and resolution phenomena in the identification and management of CGH (11,13). However, there has been no attempt to date to describe the head pain in terms of occurrence and duration to head pain resolution, and the location and intensity of head pain referral in response to testing of sustained upper cervical mobilization. For this procedure to be considered clinically useful, particularly as a diagnostic indicator of CGH, it is important to clarify that the reproduction of head pain reflects the patient's head pain experience, and that the subsequent resolution includes a significant reduction or abolition of this head pain. This series of patient cases describes these head pain responses during the performance of sustained upper cervical spine mobilization in people with probable CGH.

Cervicogenic Headache (CGH) patients

Patients described in this case series were consecutively recruited from a private physiotherapy clinic in Newcastle, Australia. Determination of an individual as presenting with probable CGH was consistent with the criteria stipulated in the International Classification of Headache Disorders version 3 (ICDH-3)(19) for CGH with the exception of the diagnostic blockade. Patients were defined as having probable CGH since, under International Headache Society criteria, a definitive diagnosis of CGH is not possible without the use of diagnostic blocks (2). Explicitly, the criteria used for probable CGH and inclusion in this case series were:

- Unilateral or side-dominant headache
- Associated neck pain or stiffness
- Headache frequency at least once per week
- History of episodic headaches for at least the previous three months
- Aged over 18 years and,
- No manual cervical treatment received in the past three months.

Patients were not included in this case series description if the headache was not of cervical origin according to the subjective screening criteria developed by the International Headache Society (19), they experienced a headache strongly associated with autonomic symptoms such as dizziness or visual disturbances, or they had any condition which might contraindicate manipulative therapy (20). Individuals with features suggestive of migraine with and without aura or bilateral symmetrical headache typifying tension-type headache were not included (19).

Examination procedures and data collection

Age, gender, and dominant head pain side were recorded for each patient. Two headache questionnaires, the La Trobe University Headache Questionnaire 1.0 (21) and the Headache Impact Test (HIT-6) (22), were administered to define the characteristics of the headaches experienced by patients.

The La Trobe University Headache Questionnaire 1.0 was used to assess headache frequency, intensity, and duration. Correlation coefficients ranging from 0.51 to 0.80 for the elements of this questionnaire have been reported matched with headache diary data (23) The Headache Impact Test (HIT-6) questionnaire measured the frequency of functional disability and evaluated emotional effects of the headache. This questionnaire has demonstrated internal consistency and test-retest reliability. When discriminating across diagnostic and headache groups, relative validity coefficients of 0.82 and 1.00 and internal consistency were observed when comparing HIT-6 total scores (22).

All patients were then assessed by an experienced physiotherapist who had 28 years of clinical experience and was currently treating at least 40 patients with headaches per week. Five sustained mobilization tests were administered by the physiotherapist to each participant. The tests assessed head pain reproduction and resolution with upper

cervical mobilization tests. All tests were performed during one assessment session for each participant.

First, with the patient in prone lying, a centrally directed posterior to anterior (P-A) passive accessory sustained mobilization technique was applied to the spinous process of C3 as described by Maitland (24) (Fig. 1a). Following this, specific unilateral techniques were applied bilaterally, following the guidelines described by Watson and Drummond (10). The C2 unilateral technique involved applying sustained P-A pressure to the superior articular surface of the axis (C2) with the participant's head in approximately 30 degrees of contralateral rotation with the patient in prone lying (Fig. 1b). The C1 unilateral technique, applied bilaterally, involved the application of a sustained P-A pressure on the middle third region of the posterior arch of the atlas (C1). With the patient supine lying, the starting position of the participant's head was in 20 degrees of contralateral rotation. With the mobilizing thumb maintained on C1, an ipsilateral rotation force of no more than 5 degrees was applied and sustained by the other hand placed on the patient's forehead (Fig. 1c).

FIGURE 1 - Mobilization techniques applied to the upper cervical spine. (a) Central C3 spinous process posterior to anterior (P-A) mobilization, (b) Left unilateral C2 sustained mobilization, (c) Right unilateral C1 sustained mobilization.

The pressure of sustained mobilization applied to each segment was determined by the patient's response. All applied passive pressures moved into joint resistance to a magnitude whereby usual head pain was reproduced or where either local neck discomfort or tissue resistance limited motion. When head pain was provoked during any sustained upper cervical mobilization technique, at the end of each procedure the participant reported the location and intensity of head pain produced both initially and following 90 seconds of sustained mobilization. Familiarity of head pain, i.e. head pain similar to the pain usually experienced, was also noted. These reports were recorded using a body chart and an eleven-point Numerical Rating Scale (NRS). The NRS has proven convergent validity with correlation coefficients ranging from 0.79 to 0.95 (25).

Any technique failing to produce or increase head pain within 15 seconds was recorded as 'clear' on the assessment. Resolution was determined by the participant reporting a reduction in the produced head pain within 90 seconds as measured by the NRS. Furthermore, the head pain was required to be similar to the participant's previous experiences of head pain.

Data Analysis

Reproduction of head pain was presented descriptively. At the start, during and end of each mobilization technique, changes in head pain intensity and time taken to achieve head pain resolution were recorded. In individuals where reproduction and resolution of usual head pain on the dominant head pain side were evident, NRS scores on initial provocation and following 90 seconds of sustained mobilization were compared using the Wilcoxon Signed-rank test. The significance level was set as $p<0.05$.

Results

Patient Demographics

Demographic and headache characteristics of the participants are presented in Table 1. The age range of headache participants was 23 to 75 years (mean 45.8 years, sd 14.8). All headache participants reported a dominant pain side. Neck pain was present in 13 of the 20 participants.

TABLE 1 - Characteristics of the headache patients assessed

Age in years (mean (SD))	45.8 (14.8)
Gender (N (%))	
Male	6 (30)
Female	14 (70)
HIT-6 score* (mean (SD))	60.6 (5.4)
Headache frequency (N (%))	
<1/month	0 (0)
1 per month	0 (0)
2-3 per month	2 (10)
1 per week	3 (15)
2-3 per week	5 (25)
4-5 per week	5 (25)
Daily	4 (20)
>1 per day	1 (5)
Headache intensity (median (IQR))	10 (5,12)
Headache duration (N (%))	
<1 hour	4 (20)
1-2 hours	7 (35)
3-5 hours	4 (20)
6-8 hours	2 (10)
9-12 hours	0 (0)
13-24 hours	2 (10)
1-2 days	1 (5)
>2 days	0 (0)
Dominant head pain side (N (%))	
Left	6 (30)
Right	14 (70)
Neck pain reported (N (%))	
No	7 (35)
Yes	13 (65)

Legend: HIT-6 = Headache Impact Test-6, IQR = interquartile range
*Score range of HIT-6 questionnaire 36 to 78.

Patient response to mobilization testing

Sixteen out of 20 (80%) participants experienced head pain reproduction and resolution within 90 seconds of the sustained upper cervical mobilization (Fig. 2). Four participants failed to experience reproduction and resolution of their usual head pain with the sustained upper cervical mobilization. Table 2 shows the response of each participant to each mobilization technique administered.

Effects of specific mobilization techniques

Each participant was assessed using five separate sustained cervical mobilization techniques. In the 16 participants who reported reproduction and resolution of head pain with any sustained cervical mobilization technique, 42.5% of applied mobilization techniques reproduced familiar head pain with resolution. Fifty percent of reproduced and resolving head pain occurred during the mobilization technique applied to C2, 47% during application of sustained mobilization at C1 and 3% upon mobilization of C3 centrally.

Relationship between mobilization testing and dominant head pain side.

Figure 2 illustrates the response to mobilization testing and its relationship to the dominant head pain side in the 16 participants who reported reproduction and resolution of head pain with sustained mobilization. Of these 16 people, the median head pain NRS score of 5 (iqr 3,6) on initial provocation reduced to 1 (iqr 0,1) following the sustained mobilization technique ($p < 0.01$). Reproduction and resolution of head pain only on the non-dominant side only occurred in two individuals where mobilization of C1 elicited this response.

Discussion

This case series aimed to describe head pain response during the performance of sustained upper cervical spine mobilization techniques. Reproduction of any head pain was always perceived on the same side as the side of the upper cervical mobilization technique, with the exception of the centrally applied C3 spinous process mobilization. This technique was perceived equally on both sides of the head. Among the 16 headache participants who demonstrated reproduction and resolution of head pain with sustained upper cervical mobilization, neither the duration (measured in seconds) nor the magnitude of reduction in head pain intensity (measured on the NRS scale) appeared markedly different across dominant head pain sides nor across segmental levels, indicating that reproduction and resolution of head pain are not dependent on head pain side dominance nor specific segmental levels.

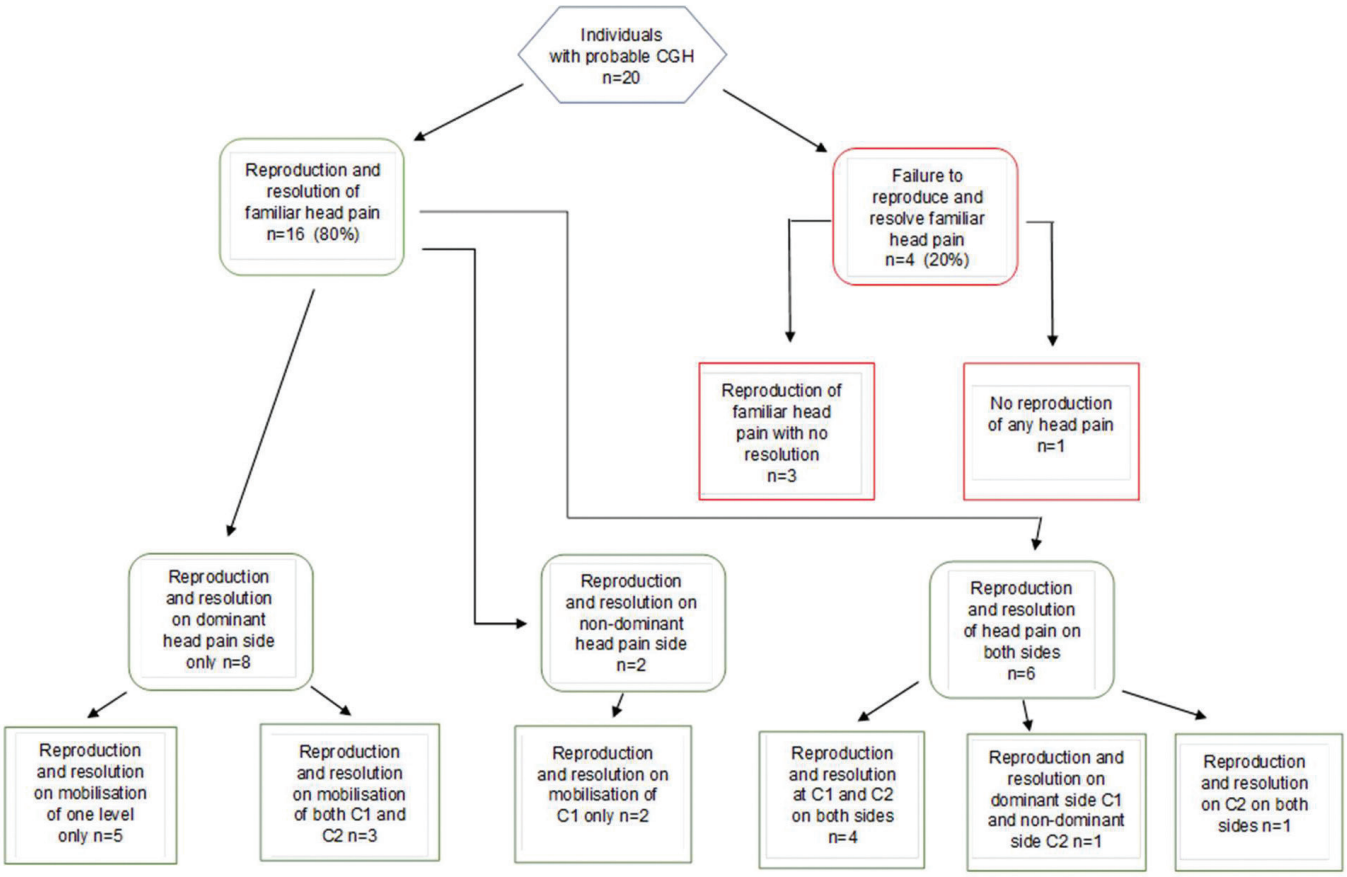

FIGURE 2 - Reproduction and resolution responses within the patient sample to sustained mobilization of the upper cervical segments.

TABLE 2 - Palpation results with respect to dominant head pain side

Participant ID	C3 central PA					C2 left unilateral PA					C2 right unilateral PA					C1 left unilateral PA					C1 right unilateral PA					Head pain reproduced and resolved YES = 1 No = 0	Dominant head pain side
	familiar/not familiar	resolved/non resolved	palpation time (secs)	NRS start	NRS finish	familiar/not familiar	resolved/non resolved	palpation time (secs)	NRS start	NRS finish	familiar/not familiar	resolved/non resolved	palpation time (secs)	NRS start	NRS finish	familiar/not familiar	resolved/non resolved	palpation time (secs)	NRS start	NRS finish	familiar/not familiar	resolved/non resolved	palpation time (secs)	NRS start	NRS finish		
Headache 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Left
Headache 2	0	0	0	0	0	0	0	0	0	0	1	0	90	2	2	1	0	90	2	2	1	1	90	3	1	1	Right
Headache 3	1	0	90	3	3	0	0	0	0	0	1	0	90	5	5	1	0	90	5	5	1	0	90	5	5	0	Right
Headache 4	0	0	0	0	0	1	0	90	2	4	0	0	0	0	0	1	1	90	2	1	1	0	90	4	4	1	Right
Headache 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	90	6	0	0	0	0	0	0	1	Right
Headache 6	0	0	0	0	0	1	1	70	2	0	1	1	90	4	2	1	1	90	3	0	1	1	90	3	1	1	Right
Headache 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	90	3	1	0	1	90	2	1	1	Left
Headache 8	0	0	0	0	0	0	0	0	0	0	1	1	90	6	0	0	1	30	2	0	1	1	90	5	4	1	Right
Headache 9	0	0	0	0	0	0	0	0	0	0	1	0	90	3	4	1	0	90	1	1	1	0	90	1	1	0	Right
Headache 10	1	1	60	8	0	1	1	70	7	0	1	1	90	8	3	1	1	90	8	2	1	1	90	8	3	1	Right
Headache 11	0	0	0	0	0	1	1	90	7	4	1	0	90	5	5	1	1	90	7	5	0	0	0	0	0	1	Left
Headache 12	0	0	0	0	0	1	1	90	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Left
Headache 13	0	0	0	0	0	1	1	70	6	0	1	1	70	5	0	1	1	45	3	0	1	1	90	3	1	1	Right
Headache 14	1	0	90	5	5	1	1	90	5	3	1	0	90	4	7	1	0	90	7	9	1	1	90	4	2	1	Left
Headache 15	0	0	0	0	0	1	1	90	2	0	1	1	50	3	0	1	1	90	3	2	1	1	90	2	1	1	Left
Headache 16	1	0	90	1	3	0	0	0	0	0	1	1	90	3	1	0	0	0	0	0	1	1	90	3	2	1	Right
Headache 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	2	0	0	0	0	0	0	Right
Headache 18	0	0	0	0	0	1	1	90	9	4	1	1	90	6	4	1	0	90	6	6	1	0	90	9	9	1	Left
Headache 19	0	0	0	0	0	0	0	0	0	0	1	1	90	6	1	1	0	0	0	0	1	0	90	2	2	1	Right
Headache 20	0	0	0	0	0	0	1	40	3	0	1	1	75	5	0	0	0	0	0	0	0	1	60	2	0	1	Right

Legend:

- Experienced reproduction and resolution of familiar head pain
- Reproduction and resolution of familiar head pain match with a dominant side
- Reproduction of familiar head pain with no resolution
- Reproduction and resolution of non-familiar head pain

NRS = Numerical Rating Scale pain intensity rating. Familiar = reproduction of familiar head pain (yes = 1, no = 0). Resolve = reduction in the produced head pain within 90 seconds of upper cervical joint mobilization by at least one point on the NRS scale (yes = 1, no = 0).

Production and resolution of head pain never previously experienced occurred during the application of some techniques suggesting that stressing upper cervical levels with sustained mobilization may produce and resolve head pain. However, it should be considered that only reproduction and resolution of *usual* head pain with sustained upper cervical mobilization may be considered a distinguishing feature of CGH.

The description of head pain responses in this series of cases also highlights the potential for multisegmental dysfunction in the upper cervical spine as a contributor to CGH. Whilst findings largely matched the application of the unilateral technique to the dominant head pain side, two participants displayed reproduction and resolution of head pain on the non-dominant head pain side. A further six headache participants displayed reproduction and resolution of head pain with mobilization testing of both the left and right sides. This potentially indicates the involvement of bilateral cervical dysfunction. Although CGH has typically been described as a unilateral headache without alteration or side shift (5,26,27), the potential for bilaterality has long been recognized (5,26,28). In cases where this presentation occurs, it is usually considered to be a consequence of the duplication of the joint disorder on the contralateral side, sometimes referred to as "unilaterality on two sides" (28). The existence of more than one locus of pain in CGH has been previously noted in respect of diagnosis by anesthetic blockade where presentations of suspected bilateral CGH are addressed through the application of multiple blockades (4). The existence of this situation is entirely plausible when we consider that CGH may be a common pathway for a number of pain-generating disorders in the cervical spine area potentially involving numerous innervated tissues (5).

Seven individuals in this sample did not experience neck pain, instead presenting with other evidence of upper cervical dysfunction such as limited passive motion. This finding is consistent with the most recent International Headache Society criteria (ICHD-3) description for CGH which states that CGH is "usually, but not invariably accompanied by neck pain". The acknowledgment of the existence of CGH without associated neck pain represents the development in the accepted description of CGH over time as a presentation that usually begins as a pain in the neck or occiput (26,27) and possibly extends into the ipsilateral arm (28) to a condition precipitated by cervical spine dysfunction but not necessarily accompanied by pain experienced in the cervical region (19).

A nociplastic pain mechanism has been suggested to be present in some individuals with chronic CGH with hyperalgesia evident in upper cervical segments and the TCN (29-31). This mechanism, whereby pain is maintained by amplified processing or decreased inhibition at multiple levels within the central nervous system (31,32), may be present alongside nociceptive pain derived from upper cervical spine joint dysfunction (33,34). The failure of head pain to resolve within 90 seconds following provocation as observed in three individuals in our case series may indicate the presence of nociplastic pain in these individuals. As nociplastic pain may be associated with preceding prolonged nociceptive inputs from peripheral structures (35), it is likely that central sensitivity may be modulated by reducing the peripheral nociceptive input (36). Sustaining the mobilization manoeuvre may result in the diminution of pre-existing sensitization by lessening referred head pain leading to reduced head pain referral and resolution of the pain (13).

In interpreting the descriptions of head pain and its response to sustained mobilization described in this case series, it should be considered that this work represents a small sample of individuals seeking care for their headache disorder in a single private clinic. Hence, the generalizability of these descriptions to a larger population of CGH patients may be limited. Additionally, patients in this series were classified as having probable CGH due to the absence of confirmation of the diagnosis by diagnostic blockade. This raises an increased possibility of misdiagnosis compared to samples derived from interventional procedures.

Conclusion

Reproduction and resolution of headache with sustained upper cervical mobilization findings in the patients reported in this case series largely matched the dominant head pain side. The bilaterality of findings was evident in this clinical series. This case series also demonstrated that CGH can present without neck pain despite underlying cervical dysfunction.

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