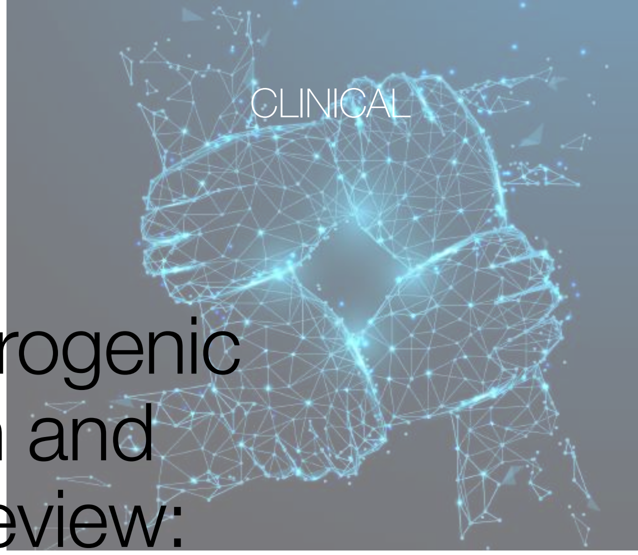
Asia-Pacific Chiropractic Journal



Neurodynamics of vertebrogenic somatosensory activation and Autonomic Reflexes - a review:

Part 8 The Cranial Nerves and the Cervical Spine

Peter Rome and John Waterhouse

Abstract: Cervicogenic correlation with the cranial nerves suggests a convenient accessibility for influencing certain syndromes, with the most recognised one being cervicogenic headaches although a number of other conditions are also noted.

Indexing terms: Vertebral subluxation; Neurophysiology; Cranial Nerves; Cervical spine.

Introduction

In regard to the cervicocranial syndrome, Lewit states that '*This syndrome covers headaches of cervical origin as well as other disturbances mainly of equilibrium, including minor neurological disorders such as nystagmus.*' (1)

Considerable evidence of spinogenic influence upon ANS innervated structures is noted through the cranial nerves. Sound physiological research and reported clinical outcomes can be a recognised vertebral factor in a range of apparent somatocranial parasympathetic conditions. Herrick utilised the term '*craniospinal*' back in 1915 in an apparent recognition of the relationship between the cranial and spinal nerves. It was also noted by Greek anatomist Herophilus, c335-280 BC. (2, 3, 4)

> *'... Considerable evidence of spinogenic influence upon ANS innervated structures is noted through the cranial nerves. Sound physiological research and reported clinical outcomes can be a recognised vertebral factor in a range of apparent somatocranial parasympathetic conditions'*

Glasgow et al recognised the cervicogenic association and the ANS under the heading '*Special significance of cervical articular innervation*.' They associated the possibility of such neurological symptoms as postural instability, vertigo, nystagmus and ataxia, when cervical articulations were compromised. (5)

Eriksen summarised examples of cranial nerve pathophysiology (particularly cranial nerves I, III, IV, VI) under manipulative care, mostly chiropractic. His text summarised eleven case reports of vision and oculomotor conditions (pp 339-44), seven papers on auditory dysfunction (pp 345-6, 391, 393), and some 40 related to cervicogenic vertigo and cervicogenic headache (pp 258-86). (6) Other authors have also identified a spinal association. (7, 8, 9, 10, 11, 12, 13)

Following whiplash injuries, Jackson acknowledged craniocervical neural connections and sympathetic communications as being '*plausible explanations*' for those symptoms. She supported manipulation for cervical joint dysfunction. She also noted that cranial structures may be disturbed due to '*irritation of the cervical sympathetic supply.'* This included neurological symptoms such as visual blurring, pain in or behind the eye, disturbances in equilibrium, tinnitus, and dysphagia. (14)

Vaňásková and colleagues noted a vertebrogenic factor with dysphagia, a condition which may involve more than one cranial nerve. They concluded '*Dynamic scintigraphy can objectify oesophageal dysfunction in patients affected by disturbed cervical function and can be used to assess success.*' (15, 16)

Zuo and colleagues identified a bidirectional neural connection between the cervical spine and sympathetic ganglia in the rabbit which was suspected of providing information explaining the pathogenesis of cervicogenic vertigo. (17)

As chiropractors, Foreman and Croft have been called as expert witnesses in whiplash litigation. They nominated a range of cranio-autonomic symptoms associated with cervical spine disturbances. These include: *Barré-Liéou syndrome*, vertigo, blurred vision, tinnitus, and transitory deafness. (18, 19)

Rieke states that the cervicollic head-righting reflex was dependent on receptor '*input of the upper two or three cervical nerves*' and the midbrain colliculus. She noted similar motor nerve contribution with the vestibulospinal and cervico-ocular reflexes. In addition Rieke found that these functional disorders of C0-C3 were noted factors in disturbance of the cervical sympathetics and proprioceptors. (20)

Olfactory Nerve (CN I)

Cases of olfactory dysfunction being resolved under chiropractic care have been recorded, while an association between the olfactory and trigeminal nerves has also been reported. (21, 22, 23, 24, 25)

Optic Nerve (CN II)

Villablanca and colleagues regard the optic nerve as not being strictly a cranial nerve as it is histologically a collection of axons, and a direct extension of a brain tract. The medical doctor Gorman noted positive outcomes in visual perception associated with cervical spine manipulation.

Other cranial nerves are noted associating the cervical spine with nystagmus (III, IV, VI). (26, 27, 28, 29, 30, 31, 32, 33)

Trigeminal (CN V)

In a 2003 review of the trigeminocervical complex in association with migraine, Bartsch and Goadsby attributed influence from the upper cervical spine in both generating and contributing to a functional relevance in migraineurs.

Two years later, Barsch noted how nociceptive input from neck structures of the upper cervical spine could influence this cranial nerve complex. In 2005, these authors noted cervicogenic sensitisation in that noxious input may occur on the central neuron level and the possible role of segmental mechanisms. (34, 35)

Some cephalalgias are recognised as an autonomic dysfunction primarily involving the trigeminal nerve and hypothalamus. The trigemino-autonomic reflex and hypothalamic activation involved with particular headaches has been described as the trigemino-cervical complex. Other headaches are recognised as being directly of cervical origin, involving the cervical spinal nerves.

It is suggested that management which is directed primarily towards pain reduction with a greater occipital nerve block, or occipital nerve stimulation, may be symptomatic approaches, when the underlying etiological influence affecting those nerves may be initiated by noxious sensory input from disturbed cervical articular facets. (36, 37, 38, 39, 40, 41, 42, 43)

The trigeminocervical complex was also implicated in a physiotherapy study on facial pain by La Touche et al, and others. (44, 45, 46, 47) They found nociceptive modulation of noxious cervical articular input led to sympathoexcitatory response. This had the capacity to beneficially affect head and facial pain as an '*hypoalgesic*' outcome. A range of symptoms are also thought to be associated with cervicogenic disturbance of the trigeminal nerve.

Eriksen has summarised six papers relating to the manipulative and manual care of patients suffering with trigeminal neuralgia. He also cited reference to a Chinese study with positive outcome of 8 of 12 patients who responded to cervical manipulation for trigeminal neuralgia. (48, 49)

In a further medical study, Giblin et al demonstrated the cervicogenic origin for certain headaches. They found that amelioration by a nerve blockade (radiofrequency ablation) of the cervical nociceptive input by lesioning the third occipital nerve, the medial branch of the posterior division of the C3 spinal nerve. This would appear to be a more biologically invasive intervention than addressing the nociceptive input from the articular surfaces by manipulative means. LaTouche et al indicated that the cervical mobilisation intervention resulted in a nociceptive modulation of the trigeminocervical complex. (39, 46, 47, 48, 49, 50, 51, 52, 53, 54)

In addition, Montétrey and Basbaum noted a possible neurospinal pathway of somatovisceral and viscerovisceral reflex activation which implicated the *trigeminal nucleus cordalis* with the *glossopharyngeal* and also the *vagus* cranial nerves. (55)

In 1989, Tamura researched the relationship of cranial symptoms with injuries to the cervical spine being the somatic factor. He found a clear correlation between C3/C4 radicular defects and the *Barré-Liéou Syndrome*. He also stated that '*one difficulty in assessing this syndrome was that cranial symptoms are related to excessive movement of the neck*', a biomechanical hypermobile segment. In this study, the compromise of the cervical nerve root sleeves was attributed to soft disc herniation. (56)

The clinical finding of a C1-C2 segment hypermobility attributed to capsular and ligament laxity associated with whiplash was also noted as being associated with neck pain and *Barré-Liéou Syndrome* by Steilin et al. Again, a vertebrogenic somatosensory element would be implicated. (57)

Certain manual procedures are designated in chiropractic and directed at separate vertebrae to counter hypermobile segments. In such cases, attention may then be directed to the adjacent, or specific nearby segments, which may have undergone compensatory locking or hypomobility. Once these fixations are released, movement is averaged out over 3 or 4 vertebrae, potentially putting less mechanical segmental stress at the hypermobile level.

Abducent Nerve (CN VI) (See also CN II)

Other than a possible connection with nystagmus (see CN N II), no evidence was found implicating the *abducent* cranial nerve under manual therapy. Like the spinal accessory nerve, it has a purely somatic motor function. The *abducent* nerve is involved with external abduction of the eye. [See also *External rectus* CN 6, *Superior oblique* CN 4, Others CN 3]

Facial Nerve (CN VII)

Facial nerve palsy (Bell's palsy) has also been noted as responding to cervical spine adjustment. This association effectively portrays integration between the cranial parasympathetic nervous system and somatic spinal influence. (58, 59, 60, 61)

Vestibulocochlear (CN VIII)

Convincing evidence as to the role of the cervical spine in relation to some forms of vestibular stability also demonstrates somato-autonomic integration. A segmental biomechanical VSC may contribute to the development of vertiginous symptoms following cervical whiplash or other cervical biomechanical disturbance. (62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72)

Independent evidence demonstrates emerging interest in a possible cervicogenic role in tinnitus. (73, 74, 75, 76, 77)

Glossopharyngeal (CN IX)

A further clinical expression of somatoautonomic (somatoparasympathetic) association is tongue-tie syndrome (ankyloglossia) in infants. (See also Part VII) (78, 79, 80, 81, 82, 83, 84, 85, 86)

Older patients with dysphonia have also been found by chiropractors and osteopaths to present with cervical spine disturbance, implicating involvement of CN IX. Case reports of resolution of these symptoms by spinal adjustments were noted. (87, 88, 89)

Vagus (CN X)

Noxious sensory input from a mechanically disturbed cervical spine has the potential to influence visceral physiology through activation of vagal nuclei notably due to its anatomical proximity to the vagal nuclei in the brainstem. The extensive vagal network has considerable parasympathetic influence on visceral function. The vagal nuclei in the brainstem have the potential to duly influence visceral physiology due to its anatomical proximity to a physically disturbed cervical spine and its noxious somatosensory input. This has been documented in the literature. Efficacious clinical outcomes through manual therapy as seen in infantile colic. In addition, research with animal subjects would independently corroborate involvement of a probable vertebrogenic factor. (90, 91, 92, 93, 94)

Evidence suggests that somatosensory activation may influence vagus nerve innervation to the heart through a '*somato-vagal reflex*'. Terui and Koizuma state that in anaesthetised dogs '*The vagus nerve discharge evoked by sinus nerve stimulation was inhibited during reflex inhibition produced by somatic nerve stimulation.*' Further, the study noted reciprocal relationship between somato-vagal and somatosympathetic reflexes in recording a cardiac response. The *sinus* nerve (or *carotid sinus* nerve) is a branch of the *glossopharyngeal* cranial nerve (IX). (95)

Depending on whether the patient was subject to SMT in a horizontal or tilted position, a 2008 study by Henley et al, found that the parasympathetic vagal response differed in its sympathetic response, as monitored through heart rate variability (HRV). It was found that parasympathetic responses were dominant in the horizontal posture. They concluded that osteopathic manipulative therapy demonstrated an association with the autonomic nervous system. They also concluded that HRV was a means by which to monitor biological response of the ANS to manipulative intervention. (96)

It is noted that not only is the *vagus* primarily a parasympathetic nerve, it also has a sympathetic nervous system element. There is mounting evidence in the medical literature of subcutaneous and transcutaneous instruments that stimulate the vagus nerves. These have been employed in a range of conditions. (97, 98, 99, 100)

Different Effects of Left and Right Vagus

New research on the use of *vagus* nerve stimulation to address postural orthostatic tachycardia syndrome (POTS), and other forms of dysautonomia was presented by Dr Dietrich from *Vanderbilt University's Autonomic Dysfunction Centre*. In a video of his address, he noted differences in innervations between the left and right vagus (101, 4:48 through to 6:30). He stated that the right vagus carries 80% of its efferent fibres to the heart, while the left vagus carries 80% of its efferents to the brain. He also discussed vagal innervation of a specific part of the ear (101, 10:58).

An earlier study concluded that '*Patients with orthostatic vasovagal reactions have impaired vagal baroreflex responses to arterial pressure changes below resting levels but normal initial responses to upright tilt. Subtle vasovagal physiology begins before overt presyncope. The final trigger of human orthostatic vasovagal reactions appears to be the abrupt disappearance of muscle sympathetic nerve activity.*' (102)

Spinal Accessory (CN XI)

The spinal accessory nerve has a cranial and a spinal root with a purely somatic function. The cranial root shares its origin with the nucleus ambiguous, and partly with the dorsal nucleus of the vagus nerve. It is primarily a somatic motor nerve and originates in the cervical portion of the spinal cord. It mainly supplies the sternocleidomastoid, trapezius, and laryngeal muscles.

When Waddell found these muscles to be weak, he addressed them by correcting dysfunction of the cervical spine through manipulation. One of his patient's impaired singing voice was monitored, and recovered following this chiropractic care. Hülse and Wood both attributed a functional deficit of the cervical spine in similar cases which were positively resolved. (103, 104, 105, 106)

Hypoglossal Nerve (CN XII)

Clinical evidence exists indicating that the cervical spine and the *hypoglossal* nerve have been implicated as factors associated with breast feeding and swallowing difficulties. These symptoms are also recorded as having responded to cervical spine manipulation, in order to normalise the cervical dysfunction and its neural influence. (14,107, 108, 109, 110)

Cranial Nerves 0 or XIII, and XIV

In researching this paper, it was interesting to discover reference to a designated Cranial nerve 0, also called the *terminal* nerve or *nervus terminalis*. It has also been named as Cranial nerve XIII. It has its origin in the lamina terminalis at the cribriform plate of the ethmoid bone (as does the *olfactory* nerve, CN I). It was initially found in animals and thought to be associated with the detection of pheromones. However, Sonne and Lopez-Ojeda state that it has been identified in humans for over a century, but remains unrecognised in much of the medical literature. It appears to be associated with gonadotropin releasing hormones and other functions. (111, 112, 113)

The authors note the identification of a Cranial nerve XIV. According to Bordoni and Zanier, it is referred to as *nervus intermedius* and lies between cranial nerves VII and VIII. They also emphasised the importance of nerve variables to surgeons, chiropractors, osteopaths, and other manual therapists. (114)

As case reports continue to mount, (115) it is suggested that due to the anatomical level of their origin most cranial nerves as well as their proximity to the cervical spine, when manipulative care is indicated, a need for segmental specificity is critical.

As a further possible anatomical integration with the cervical spine, Menétrey and Basbaum suggested that the nucleus of the *tractus solitaries* may act as a relay for somatic and visceral afferents through cranial nerves, *Trigeminal* (V), *Glossopharyngeal* (IX), *Vagus* (X), and *Spinal Accessory* (XI). That research was conducted on rat specimens and as such, the role of the cervical spine would appear to be central, but also necessitates the avoidance of sensory irritation originating from the cervical spine. (116)

Conclusion

The integration of the cervical spine with the parasympathetic cranial nerves provides an opportunity to influence a range of pathophysiological conditions.

Peter Rome
DC (ret), FICC
cadaps@bigpond.net.au

John D Waterhouse
DC, FACC
Private practice, Melbourne

Cite: Rome P. Waterhouse JD. Neurodynamics of vertebrogenic somatosensory activation and Autonomic Reflexes - a review: Part 8 The Cranial Nerves and the Cervical Spine. Asia-Pacific Chiropr J. 2021;1.4. URL apcj.net/papers-issue-2-4/#RomeWaterhousePart8CranialNerves

References

1. Lewit K. Manipulative therapy in rehabilitation of the locomotor system. 3rd ed. Oxford. Butterworth Heinemann.1999:268.
2. Cauwenbergs P. Vertebral subluxation and the anatomic relationships of the autonomic nervous system – Parasympathetic cranial nuclei and their peripheral distribution. In: Gatterman MI. Foundations of Chiropractic. 2nd ed. St Louis, Elsevier Mosby. 2005;324-329.
3. Leach RA. Somatoautonomic dysfunction - somatoautonomic imbalance. In: The chiropractic theories. 3rd ed. Baltimore. Williams & Wilkins. 1994:108-19.
4. Herrick CJ. An introduction to neurology. Philadelphia: WB Saunders Co; 1915;223. [Brain Architecture Management Systems. University of Southern California .https://bams2.bams1.org/thesaurus/list/by_ref/herrick-cj-1915/]
5. Glasgow EF, Twomey LT, Scull ER, Kleynhans AM, Idczak RM. Aspects of manipulative therapy. Edinburgh; Churchill Livingstone, 1985;75-76
6. Eriksen K. Upper cervical subluxation complex. A review of the chiropractic and medical literature. Philadelphia: Lippincott Williams & Wilkins;2004
7. Menétrey D, Basbaum AL. Spinal and trigeminal projections to the solitary tract: a possible substrate for somatovisceral and viscerosomatic reflex activation. J Comp Neurol. 1987;1255(3):439-450.
8. Ziegler E. [Connections between changes of the cervical spine and diseases in the cranial region; chiropractic therapy]. Munch Med Wochenschr. 1954 Aug 27;96(35):977-9. [Article in German]
9. Rosomoff HL. Occult respiratory and autonomic dysfunction in craniovertebral anomalies and upper cervical spinal disease. Spine 1986;11(4):345-7.
10. Zhang N, Xiaohua H. Understanding the extraocular muscles and oculomotor, trochlear, and abducens nerves through stimulation in physical examination training: an innovative approach. J Chiropr Educ. 2010;24(2):153-8.
11. Jean A. [The nucleau tractus solitaries: neuroanatomic, neurochemical and functional aspects.] Arch Int Physiol Biochem Biophys. 1991;99(5):A3-52. (French) (Abstract)

12. Zhang CJ, Wang Y, Lu WQ, et al. [Study on cervical visual disturbance and its manipulative treatment.] J Trad Chinese Med 1984;4(3):205-210 (Title only)

13. Svatko LG, Ivanichev GA, Sobol IL. [Manual therapy of various forms of auditory function disorders caused by pathology of the cervical spine. Vestnik Otorinolaringologii 1987(2):28-31

14. Jackson R. The cervical syndrome. 3rd edn. Springfield. Charles C Thomas.1966;141-142,162, 284

15. Vaňásková E, Hep A, Vižďa J, Tosnerová V. Swallowing disorders related to vertebrogenic dysfunction. Ceska a Slovenska Neurologie a Neurochirurgie 2007;70(6):692-696. In: Brzozowski T (Ed.). New advances in the basic and clinical gastroenterology., ISBN: 978-953-51- 0521-3; 2012. Rijeka, Croatia; In: Tech. 2012 p175-184 http://www.intechopen.com/books/new-advances-in-the-basic-and-clinicalgastroenterology/swallowing-disorders-related-to-vertebrogenic-dysfunctions.

16. Vaňásková E, Hep A, Lewit V, et al. Cervical dysfunction with disturbed oesophageal motility – scintigraphic assessment. J Orthop Med. 2001;23(1):9-11. (Abstract)

17. Zuo J, Han J, Qiu S, et al. Neural reflex pathway between cervical spinal and sympathetic ganglia in rabbits: implication for pathogenesis of cervical vertigo. Spine J. 2013 Nov 28. pii: S1529-9430(13)01871-8. DOI 10.1016/j.spinee.2013.11.031

18. Foreman SM, Croft AC. Whiplash injuries The cervical acceleration/deceleration syndrome. 3rd edn/Philadelphia. Lippincott Williams & Wilkins.2002;25-26,447-448,548-553.

19. Maigne R. Posterior cervical "syndrome" of Barré and Liéou and subjective syndrome of head and trauma. In: Orthopaedic Medicine. A new approach to vertebral manipulation. Springfield. Charles C Thomas Publisher. 1972, Chapter 18,192-206.

20. Rieke CC. Symptoms of imbalance associated with cervical spinal pathology. Thesis. Washington University School of Medicine. May 15, 2009:12-13. https://vdocuments.site/symptoms-of-imbalance-associated-with-cervical-spine-pathology-2017-02-14-lesions.html

21. Pilling P. Alzheimer's disease, olfactory dysfunction, and chiropractic care; a case report. Abstract of ACC Conference Proceedings.: Poster presentations [2011 Association of Chiropractic Colleges Education Conference XVIII and Research Agenda Conference XVI] J Chiropr Educ 2011;25(1):106-120.

22. Carney CL, MacCarthy M, Girdis C.Resolution of post-traumatic anosmia following Network Spinal Analysis care: a case report. Annals Vertebral Sublux Res 2017;Feb:8-14

23. Blöm G. Resolution of anosmia and ageusia following knee chest upper cervical specific chiropractic care: a case report. J Upper Cerv Chiropr Res 2014;1:14-16

24. Filosa DA. A remission of anosmia and ageusia following chiropractic adjustments. Res Forum 1988;4(2):43-45

25. Frasnelli J, Schuster B, Hummel T. Olfactory dysfunction affects thresholds to trigeminal chemosensory sensations. Neurosci Lett 2010;468(3):259-263.

26. Villablanca P, Curran J, Arnold A, Lufkin R. Orbit and optic nerve. Top Magn Reson Imaging 1996;8(2):87-110

27. Rea P. Optic nerve. In: Clinical anatomy of the cranial nerves. Cambridge: Academic Press: 2014:7-26. https://doi.org/10.1016/C2013-0-19192-1

28. Gorman RF. The treatment of presumptive optic nerve ischemia by spinal manipulation. J Manipulative Physiol Ther. 1995;18(3):172-7.

29. Gorman RF. The treatment of visual perception by spinal manipulation: a prospective, peer reviewed, study of twelve consecutive patients. Poster presentation at the 24th Annual Congress of ther Australian Colleg of Ophthmalologists. 1992.

30. Hülse M. [The differentiation between the reflex cervical nystagmus and the vascular cervical nystagmus. (author's transl)] HNO 1982;30(5):192-197. (German) (English abstract)

31. Moser M, Simon H. [Nystagmus as an objective assessment of the cervical spine syndrome and its treatment. HNO 1977;25(8):265-268.

32. Reker U. [Function of proprioceptors of the cervical spine in the cervico-ocular reflex.] HNO 1985;33(9):426-429.

33. Cade A. Chiropractic intervention and control of eye movement in children with attention deficit hyperactivity disorder:a pilot study. Masters Dissertation. Auckland University of Technology. 2017

34. Bartsch T, Goadsby PJ. The trigeminocervical complex and migraine current concepts and synthesis. Curr Pain Headache Rep. 2003;7(5):371-6

35. Bartsch T, GoadsbyPJ. Anatomy and physiology of pain referral patterns in primary and cervicogenic headache disorders. Headache Currents. 2005;2(2):42-48

36. Antonaci F, Ghirmai S, Bono G, Sandrini G, Nappi G. Cervicogenic headache: evaluation of the original diagnostic criteria. Cephalalgia. 2001;21(5):573-83.

37. Lambu G, Matharu MS. Trigeminal autonomic cephalalgias: a review of recent diagnostic, therapeutic and pathophysiological developments. Annals Indian Acad Neurol. 2012;15(Wuppl 1):S51-S61,

38. Nardone R, Ausserer H, Bratti A, et al. Trigemino-cervical reflex abnormalities in patients with migraine and cluster headache. Headache 2008;48(4):578-585. DOI 10.1111/j.1526-4610.2008.00529.x.

39. Rodine RJ, Acker P. Trigeminal neuralgia and chiropractic care. A case report. J Canad Chiropr Accos. 2010;54(3):177-186

40. Schaller B. Trigeminocardiac reflex. A clinical phenomenon or a new physiological entity? J Neurol. 2004;251(6):658-665.

41. Sjaastad O. The headache of challenge in our time: cervicogenic headache. Funct Neurol 1990;5(2):155-158.

42. Vernon H. Spinal manipulation and headaches of cervical origin. J Manipulative Physiol Ther 1989;12(6):455-466

43. Zielinski E, Acanfora M. Resolution of trigeminal neuralgia following subluxation based chiropractic care: a case study and review of the literature. Ann Vert Sublux Res 2013;3:33-45.

44. La Touche R, Paris-Alemany A, Mannheimer JS, et al. Does mobilisation of the upper cervical spine affect pain sensitivity and autonomic nervous system function in patients with cervicocraniofacial pain? A randomised-controlled trial. Clin J Pain. 2013;29(3):205-215.

45. Armijo Olivio S, Magee DJ, Parfitt M, Major P, Thie NM. The association between the cervical spine, the stomatognathic system, and craniofacial pain: a critical review. J Orofac Pain. 2006;20(4):271-287.

46. Giblin K, Mewmarh JL, Brenner GJ, Wainger BJ. Headache plus: trigeminal and autonomic features in a case of cervicogenic headache responsive to third occipital nerve radiofrequency ablation. Pain Med. 2014;15(3):473-478. DOI 10.1111/pme.12334.

47. Pettman E. Trigeminal sympatoms of cervical origin. http://erlpettman.com/erls-pearls/trigeminal-symptoms-of-cervical-origin/. 2008.

48. Eriksen K, (5) pps 327-333

49. Liu SJ, Shen ZX, Cao GL. Manipulative treatment of 12 cases of cervical spondylosis with trigeminal neuralgia. J Trad Chinese Med, 1982;2:115-118 (Cited by Eriksen)

50. Bartsch T. Migraine and the neck: new insights from basic data. Curr Pain Headache Rep. 2005;9(3):191-196

51. Ailani J. A practical approach to autonomic-dysfunction in patients with headache. Curr Neurol Neurosci. 2016;16(5):41. DOI 10.1007/s11910-016-0641-x

52. May A. Diagnosis and clinical feartures of trigeminao-autonomic headaches. Headache. 2013;53(9):1470-1478.

53. Vernon H, Sun K, Zhang Y, Yu X-M, Sessie BJ. Central sensitization induced in trigeminal and upper cervical dorsal horn neurons by noxious stimulation of deep cervical paraspinal tissues in rats with minimal surgical trauma. J Manipulative Physiol Ther 2009;32(7):506-514

54. La Touche R, Fernández-de-Las-Peñas, Fernández-Carnero J, et al. Bilateral mechanical pain sensitivity over the trigeminal region in patients with chronic mechanical neck pain. J Pain. 2010;11(3):256-63.

55. Montétrey D, Basbaum AI. Spinal and trigeminal projections to the nucleus of the solitary tract: a possible substrate for somatovisceral and viscerovisceral reflex activation. J Comp Neurol 1987;255(3):439-450.

56. Tamura T. Cranial symptoms after cervical injury. Aetiology and treatment of the Barré-Liéou syndrome. J Bone Joint Surg. 1989;71-B(2):283-7.

57. Steilen D, Hauser R, Woldin B, Sawyer S. Chronic neck pain: making the connection between capsular ligament laxity and cervical stability. Open Orthop J. 2014;8:326-345.

58. Cotton BA. Chiropractic care of a 47-year-old woman with chronic Bell's palsy: a case study. J Chiropr Med 2011;10(4):288-293

59. Alcantara J, Plaugher G, van Wyngarden DL. Chiropractic care of a patient with vertebral subluxation and Bell's palsy. J Manipulative Physiol Ther 2003;26(4):253.

60. Boneva D, Kessinger R. Bell's palsy and the upper cervical spine. Chiropr Res J 1999;6(2):47-56

61. Gordon S. Chiropractic management of a combined neonatal brachial plexus and facial nerve palsy. J Clin Chiropr Pediatr 2011;12(1):879-882.

62. Magnusson M, Malmström EM. The conundrum of cervicogenic dizziness. Handb Clin Neurol. 2016;137:365=369. DOI 10.1016/B978-0-444-63437-5.00026-1.

63. Lane D. Chiropractic for the treatment of vestibular disorders. Vestibular Disorders Assoc. https://vestibular.org/sites/default/files/page_files/Documents/Chiropractic.pdf

64. Macefield VG, Hammam E, Bolton P. Vestibulo-sympathetic interactions revealed by electrical stimulation studies in humans. Auton Neurosci 2015;192:42. DOI https://doi.org/10.1016/j.autneu.2015.07.385

65. Brunarski DJ. Autonomic nervous system disturbances of cervical origin including disorders of equilibrium. In: Vernon H. ed. Upper Cervical Syndrome: Chiropractic Diagnosis and Treatment. Williams & Wilkins, Baltimore. 1988.

66. Ndetan H, Hawk C, Sekhon VK, Chiusano M. The role of chiropractic care in the treatment of dizziness or balance disorders: analysis of National Health Interview Survey data. J Evidence-based Complement Altern Med 2016. http://www.ncbi.nlm.nih.gov/pubmed/26362851

67. Holt KR, Noone PL, Short K, Elley CR, Haavik H. Fall risk profile and quality of life status of older chiropractic patients. J Manipulative Physiol Ther. 2011;34(2):787-87.

68. Holt KR, Haavik H, Elley CR. The effects of manual therapy on balance and falls: a systemic review. J Manipulative Physiol Ther. 2012;35(3):227-234.

69. Hain TC. Cervical vertigo. The American Hearing Research Foundation. http://american-hearing.org/disorders/cervical-vertigo/. Oct 2012.

70. Bolton PS. Hammam E, Kwok K, Macefield VG. Skin sympathetic nerve activity is modulated during slow sinusoidal linear displacements in supine humans.Front Neurosci. 2016; 16;10:39. DOI 10.3389/fnins.2016.00039.

71. Griffing C, Choong WY, The W, Busxton AJ, Bolton PS. Head and cervical spine posture in behaving rats: implications for modelling human conditions involving the head and cervical spine. Anat Rec (Hoboken). 2015 Feb;298(2):455-62. DOI 10.1002/ar.23049. Epub 2014 Sep 22.

72. L'Heureau-Lebeau B, Godbout A, Berbiche D, Saliba I. Evaluation of paraclinical tests in the diagnosis of cervicogenic dizziness. Otol Neurotol. 2014;35(10:1858-1865

73. Michiels S, van der Wal AC, Nieste E, et al. Conservative therapy for the treatment of patients with somatic tinnitus attributed to temporomandibular dysfunction: study protocol of a randomised controlled trial. Trials. 2018;19:554/

74. Michiels S, de Hertogh W, Truiien S, van der Hevning P. Physical therapy treatment in patients suffering from cervicogenic somatic tinnitus: study protocol for a randomized controlled trial. Trials. 2014;15:297.

75. Michiels S, Sanchez TG, Oron Y, Gilles A. Diagnostic criteria for somatosensory tinnitus: a Delphi process and face-to-face meeting to establish consensus. Trends Hear. 2018;22: 2331216518796403.

76. Oostendorp RA, Bakker I, Elvers H, et al. Cervicogenic somatosensory tinnitus: an indication for manual therapy" Part 1: theortical concept. ManTher 2016;23:120-123.

77. Yaseen K, Hendrick P, Ismail A, Felemban M, Alshehri MA. The effectiveness of manual therapy in treating cervicogenic dizziness: a systematic review. J Phys Ther Sci 2018;30(1):96-102

78. Terrett, AGJ. Neck-tongue syndrome and spinal manipulative therapy. In: H Vernon (Ed.) Upper cervical syndrome: chiropractic diagnosis and treatment. Williams & Wilkins, Baltimore; 1988: 223–229

79. Lois, I. The cervicolingual syndrome. Man Med. 1987; 3: 63–66

80. Hankey, GJ. Neck-tongue syndrome on sudden neck rotation. Aust N Z J Med. 1988;18(2):181.

81. Borody C. Neck-tongue syndrome. J Manipulative Physiol Ther. 2004;27(5):357. e8.

82. Buroon M, Pero J. Resolution of glossopharyngeal neuralgia & spastic dystonia following chiropractic care to reduce upper cervical vertebral subluxation: A case study [case report]. J Upper Cervical Chiropr Res. 2014:1:7-13.

83. Cassidy JD, Diakow PRP, De Korompay VL, Munkacsi I, Yong-Hing K. Treatment of neck-tongue syndrome by spinal manipulation. Pain Clinic. 1986;1(1):41-46. https://pdfs.semanticscholar.org/3cf6/f72448957512d1548c97701583cd02f233f3.pdf

84. Gelfand AA, Johnson H, Lenaerts ME, et al. Neck-tongue syndrome: a systemic review. Cephalalgia. 2018;38(2):374-382

85. Lavigne V. A narrative review and case report. Frenotomy procedure in neonate with tongue-tie. J Clin Chiropr Pediatr. 2012;13(2):1025-1031.

86. Niethamer L, Myers R. Manual therapy and exercise for a patient with neck-tongue syndrome a case report. J Orthop Sports Phys Ther. 2016;46(3):217-224. DOI 10.2519/jospt.2016.6195. (Designated as C2)

87. Buroon M, Pero J. Resolution of glossopharyngeal neuralgia and spastic dystonia following chiropractic care to reduce upper cervical vertebral subluxation: a case study. J Upper Cervical Chiropr Res. 2014;1:7-113.

88. Waddell RK. Chiropractic care for a patient with spasmodic dysphonia associated with cervical spine trauma. J Chiropr Med. 2005;4(1):19-24.

89. Wood KW. Resolution of spasmodic dysphonia (focal laryngeal dysphonia) via chiropractic manipulative management. J Manipulative Physiological Ther. 1991;15(6):376-378

90. Sato A, Sato Y, Schmidt RF. The impact of somatosensory input on autonomic functions. In: Blaustein MP, Grunicke H, Pette D, Schultz G, Schweiger M. (eds). Rev Physiol Biochem Pharmacol. Berlin: Springer;1997;130:170,183,185-6.

91. Koizumi K, Sato A. Reflex activity of single sympathetic fibres to skeletal muscle produced by electrical stimulation of somatic and vago-depressor afferent nerves. Arch Ges Physiol 1972;332:283-301.

92. Rubin D, Wilson H, Harward R. Improvement in autiostic behaviors following chiropractic care. The application of polyvagal Theory and its relationship in pediatric chiropractic (case report). J Pediatr Matern & Fam Health 2016;3:80-93

93. Fludder CJ, Keil BG. Presentation of neonates and infants with spinal vs extremity joint dysfunction. Chiropr J Aust 2018;46(1):79=91.

94. Welch, A., Boone, R. Sympathetic and parasympathetic responses to specific diversified adjustments to chiropractic vertebral subluxations of the cervical and thoracic spine. J Chiropr Med. 2008;7:86–93.

95. Terui N, Koizuma K. Responses of cardiac vagus and sympathetic nerves to excitation of somatic and visceral nerves. Autonomic Neurosci: Basic & Clinical 984;10(2):73-91.

96. Henley CE, Ivins D, Mills M, Wen FK, Benjamin BA. Osteopathic manipulative treatment and its relationship to autonomic nervous system activity as demonstrated by heart rate variability: a repeated measures study. Osteopath Med Prim Care. 2008 Jun 5;2:7. DOI 10.1186/1750-4732-2-7.

97. Tobaldini E, Toschi-Dias E, de Sousa LA, et al. Cardiac and peripheral autonomic responses to orthostatic stress during transcutaneous vagus nerve stimulation in healthy subjects. J Clin Med. 2019;8;496; DOI 10.3390/jcm8040496.

98. Kreuzer PM, Landgrebe M, Resch M, et al. Feasibility, safety and efficacy of transcutaneous vagus nerve stimulation in chronic tinnitus" an open pilot study. Brain Stimul. 2014;7:740-7.

99. Gadze ZP, Kovac AB, Adamec I, et al. Vagal nerve stimulation is beneficial in postural orthostatic tachycardia syndrome and epilepsy. Seizure. 2018;57:11-13. https://www.seizure-journal.com/article/S1059-1311(18)30011-6/pdf

100. Teckentrup V, Neubert S, Santiago JCP, et al Non-invasive stimulation of vagal afferents reduces gastric frequency. Brain Stimul. 2020;13(2):470-3.

101. Diedrich A. Vagus nerve stimulation in POTS. Presentation at the Dysautonomia 6th International Conference. Nashville. June 23, 2018. https://vimeo.com/282519866 (1/2 hour lecture)

102. Morillo CA, Eckberg DL, Ellenbogen KA, et al. Vagal and sympathetic mechanisms in patients with orthostatic vasovagal syncope. Circulation. 1997;96(8):2509-13.

103. Waddell RK. Chiropractic care for a patient with spasmodic dysphonia associated with cervical spine trauma. J Chiropr Med. 2005;4(1):19-24.

104. Hülse M. [Functional dysphonia following cervical spine trauma.] Laryngorhinologie. 1991;70(11:599-603.

105. Wood KW. Resolution of spasmodic dysphonia (focal laryngeal dystonia) via chiropractic manipulative management. J Manipulative Physiol Ther. 1991;14(6):376-378.

106. Mathieson L, Hirani SP, Epstein R,Baken RJ, Wood G, Rubin JS. Laryngeal manual therapy: a preliminary study to examine its treatment effects in the management of muscle tension dysphonia. J Voice 2009;23(3):353-366

107. Alcantara J, Alcantara JD, Alcantara J. The chiropractic care of infants with breastfeeding difficulties. Explore (NY) 2015;11(6):468-474

108. Holleman AC, Nee J, Knaap SFC. Chiropractic management of breast-feeding difficulties: a case report. J Chiropr Med. 2011;10(3):199-203.

109. Miller JE, Miller L, Sulesund AK, Yevtushenko A. Contribution of chiropractic therapy to resolving suboptimal breastfeeding: a case series of 114 infants. J Manipulative Physiol Ther 2009;32(8):670-674

110. Webb J. March L, Tyndall A. The neck-tong103ue syndrome: occurrence with cervical arthritis as well as normal. J Rheumatol 1984;11(4):530-533

111. Vilensky JA. The neglected cranial nerve: nervus terminalis (cranial nerve N) Clin Anat. 2014;27(1):46-53. https://pubmed.ncbi.nlm.nih.gov/22836597/

112. Sonne J, Reddy V, Lopez-Ojeda W. Neuroanatomy, Cranial nerve 0) (Terminal nerve). Treasure Island. StatPearls. 2020. https://pubmed.ncbi.nlm.nih.gov/29083731/

113. Alfieri A, Strauss C, Prell J, Peschke E. History of the nervus intermedius of Wrisberg. Ann Anat. 2010;192(3):139–44. https://pubmed.ncbi.nlm.nih.gov/?term=alfieri+nervus

114. Bordoni B, Zanier E. Cranial nerves XIII and XIV: nerves in the shadows. J Multidiscip Healthcare 2013;6:87-91. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3601045/

115. Briegel L, Briegel L, Resolution of sensorineural hearing loss in a 9-year-old child following chiropractic care to reduce vertebral subluxation: a case report & review of the literature. J Pediatr Maternal Family Health; 2021; March 15:26-31

116. Menétrey D, Basbaum AI. Spinal and trigeminal projections to thr nucleus of the solitary tract: a possible substarate for somatovisceral and viscerovisceral reflex activation. J Comp Neurol 1987;255(3):439-450.