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The Vertebral Subluxation premise:

Principle 1 continued, The medical literature regarding nomenclature and onset

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Narrative: This is the second of a 6-paper series which presents a descriptive narrative of the Western medical literature to identify and report evidence for each of the five principles of the Vertebral Subluxation Complex (VSC) premise as established in 1947 by Janse, Houser, and Wells (National College of Chiropractic). This literature is additional to that from the chiropractic perspective which is available in the electronic *Index to Chiropractic Literature*.

The first part of this paper introduced the series and gave evidence to establish Principle One that '*a vertebrae may subluxate*'. This second paper as Part 2 presents the evidence for Principle One by documenting the evidence for the onset of a Vertebral Subluxation Complex.

This 6-part series describes the incontrovertible acknowledgement and weight of recognition of the effect of physical, biomechanical, and physiological vertebral disturbances collectively contributing to the VSC and demonstrates strong support of the chiropractic nomenclature, neurophysiological and clinical implications of the Vertebral Subluxation Complex as recorded in the medical literature.

Indexing terms: Subluxation; Vertebral Subluxation Complex (VSC); onset; vertebral dysfunction.

Editor's note:

Rome and Waterhouse have together perhaps the most thorough understanding of the medical literature from the mid 20th Century to this moment in respect to its voluminous descriptions of spinal lesions known to chiropractors as indicative of the Vertebral Subluxation Complex (VSC).

> *... Principle 1 of the VSC is that a vertebra may subluxate. This paper reports the evidence for the modes of onset of the VSC ...'*

This second paper in our new series of 6 papers concludes the discussion on Principle 1, that a vertebra may subluxate in reference to its contiguous segments. In particular, this paper addresses the causative factors.

The reporting of Rome and Waterhouse is so extensive that the *Journal* is publishing these 6 papers over 2 issues, (Part 1 is here). This paper concludes Principle 1 as part 2, with Principle 2 here, Principle 3 here, Principle 4 here, and Paper 6, Principle 5 here. These papers are also collected on the *Journal* website as 'MasterClasses' as an invaluable reference base. To this end, each key element of this paper is immediately supported by a compendium of source references, a departure from the usual practice of collecting cited references at the end of the work.

Phillip Ebrall, Editor

This series to date ...

The first paper, Part Part 1 of Principle One, established that the clinical practices of Chiropractic, manipulative medicine and Osteopathy collectively recognise the biomechanical and physiological phenomena and associated neural ramifications of spinal lesions.

We presented the preponderance of papers from the field of manipulative or biomechanical medicine which support the chiropractic nomenclature of of the Vertebral Subluxation Complex. We continue by reporting the literature relating to the onset of spinal dysfunctions known by Chiropractors as the VSC.

Introduction to Paper 2, Principle 1 *conc.*

'*Factors that may initiate a biomechanical disturbance involving the dysfunction and/or displacement comprise a subluxation complex*'

Causative factors are basically considered to be physical, chemical, or psychological, alone or in any combination. It may be argued that physical forces may constitute the most common. It is suggested that each may exacerbate another. These may be sudden trauma, gradual postural stress, strains and sprains from activity, stress and tension. (NZCA undated) (Schafer, 2022a)

In many cases the intersegmental holding elements may not be damaged as the fixation and displacement usually occurs within the normal range of motion. More severe intersegmental sprains resulting in a VSC may well disrupt ligamentous and discal fibres but may still respond to manipulative care accompanied with other measures.

Forces may contribute to changes in joint motion with or without pathophysiological displacement of the associated articulation(s). These include:

- Trauma, macro and micro from birth injuries, falls, motor vehicle accidents, whiplash, sporting injuries
- Strain such as lifting, repetitive activities, minor sports injuries
- Posture poor habits including prolonged sitting
- Noxious sensory bombardment from other somatic irritants
- Hypertonicity of both intrinsic and skeletal muscles: this may be present as muscle splinting or spasms resulting in reduced segmental motion or dysfunction
- Hypotonicity may also be a factor in certain cases with possible segmental instability and dysfunction
- Congenital anomalies and the disturbances these may introduce
- Lack of flexibility.

Trauma from Whiplash (WAD syndrome)

A relatively common and severe cause of VSCs are whiplash injuries. When this type of injury is noted as a hyperflexion, hyperextension, or combined hyperflexion/hyperextension (or vice versa) and depending on the severity of the incident, they may present with radiological evidence. This type of injury does not necessarily have to involve a motor vehicle accident, but also incidents such as falls, sporting injuries, head-first falls, trampoline injuries, are other typical examples of subluxations of a mechanical origin under forced extreme ranges of motion – and complicated by the presence of pre-existing condition(s) at the time of injury. (Sato, 2019)

In her early and extensive discourse on whiplash in 1966, Jackson noted many of the findings noted by disturbed *mechano-dynamics* (p. 131). She was an early advocate of the Davis series of

radiological examination in such cases, and recognised neck manipulation (p. 284), nerve irritation (p. 72, 74), and the subluxation(p. 179 - 195).

Whiplash and its adverse effects on vertebral mechanics is a topic in itself. It is potentially one of the more severe causes for the more serious and chronic conditions because of soft tissue damages. By the same token, it is a condition from which symptomatic relief is often readily obtained. Consequently, it is only acknowledged in this presentation as it provides classic examples of one of the causes related to symptoms of spinal mechanical disruption. (Hinoki, 1984; Fast et al, 2002; Nordhoff, 2005; Storaci et al, 2006; Bogduk, 2011; Gatterman, 2012; Tanaka et al, 2018; Côté et al, 2019; Al-Khazali et al, 2020; Hage et al, 2021; Parravicini et al, 2021; Siegmund et al, 2009)

Subject to the degree of tissue damage and segmental disturbance the acute and chronic somatosensory insult from such an injury may make it particularly suitable for manipulative correction. This is reflected in the following abstract from Woodward et al.

'*Forty-three per cent of patients will suffer long-term symptoms following "whiplash" injury", for which no conventional treatment has proven to be effective. A retrospective study was undertaken to determine the effects of chiropractic in a group of 28 patients who had been referred with chronic "whiplash" syndrome. The severity of patients' symptoms was assessed before and after treatment using the Gargan and Bannister* (1990) *classification. Twenty-six (93 per cent) patients improved following chiropractic treatment (U =34, P <0.OOl). The encouraging results from this retrospective study merit the instigation of a prospective randomized controlled trial to compare conventional with chiropractic treatment in chronic "whiplash" injury*. (Woodward et al, 1996) (Bannister et al, 2009)

The severity and chronicity of whiplash symptoms can be significant. The evidence suggests that neck pain in particular has the potential for a wider range of symptoms. In the authors' opinions, it is unfortunate for patients that greater use of chiropractic care is not afforded whiplash patients. (Astrup et al, 2022)

Even this paper noted two distinct terms; *sensorimotor incongruence* (Don et al, 2016) and *cervical spinal dyssynergia* (Astrup et al, 2022) which tend to emphasise the complex nature of the term , whiplash. While dyssynergia can also be associated with movements in more complex cerebellar disorders, its inclusion portrays the complex significance in whiplash.

The topic of management of hypermobile or unstable segmental conditions is discussed later in this document.

Although there can be a range of causes, dull back aches, intermittent aches, pain initiated by activities or poor postures may become recurring factors in perpetuating a subluxation as in the form of a noxious somato-somatic reflexes leading to hypertonic musculature. (MSU, 2007)

Extended reference compilation

Whiplash trauma

Al-Khazali HM, Ashina H, Iljazi A, Lipton RB, Ashina M, Ashina S, Schytz HW. Neck pain and headache after whiplash injury: a systematic review and meta-analysis. Pain. 2020 Bannister G, Amirfeyz R, Kelley S, Gargan M. Whiplash injury. J Bone Joint Surg Brit. 2009;91-B(7): https://online.boneandjoint.org.uk/doi/full.

Astrup J, Gyntelberg F, Johansen AM, Lei A, Marott JL. Impaired neck motor control in chronic whiplash and tension-type headache. Acta Neurol Scand. 2021 Oct;144(4):394-399. DOI 10.1111/ane.13473. Epub 2021 May 21.

Astrup J, Gyntelberg F. The whiplash disease reconsidered. Front Neurol. 2022 Mar 10;13:821097. DOI: 10.3389/fneur.2022.821097.

Bogduk N. On cervical zygapophysial joint pain after whiplash. Spine (Phila Pa 1976). 2011 Dec 1;36(25 Suppl):S194-9.

Côté P, Yu H, Shearer HM, Randhawa K, et al. Non-pharmacological management of persistent headaches associated with neck pain: A clinical practice guideline from the Ontario protocol for traffic injury management (OPTIMa) collaboration. Eur J Pain. 2019 Jul;23(6):1051-1070. DOI 10.1002/ejp.1374. Epub 2019 Feb 28. PMID: 30707486.

Daenen L, Nijs J, Roussel N, Wouters K, Cras P. Altered perception of distorted visual feedback occurs soon after whiplash injury: an experimental study of central nervous system processing. Pain Physician. 2012 Sep-Oct;15(5):405-13.

Don S, De Kooning M, Voogt L, Ickmans K, Daenen L, Nijs J. The effect of visual feedback of the neck during movement in people with chronic Whiplash-Associated Disorders: An Experimental Study. J Orthop Sports Phys Ther. 2017 Mar;47(3):190-199. DOI 10.2519/jospt.2017.6891. Epub 2017 Feb 3.

Don S, Voogt L, Meeus M, De Kooning M, Nijs J. Sensorimotor incongruence in people with musculoskeletal pain: a systematic review. Pain Pract. 2017 Jan;17(1):115-128. DOI 10.1111/papr.12456. Epub 2016 May 21.

Drottning M, Staff PH, Sjaastad O. Cervicogenic headache (CEH) six years after whiplash injury. Funct Neurol. 2007 Jul-Sep;22(3):145-9. PMID: 17925163.

Drottning M. Cervicogenic headache after whiplash injury. Curr Pain Headache Rep. 2003 Oct;7(5):384-6. DOI 10.1007/s11916-003-0038-9. PMID: 12946292.

Fast A, Sosner J, Begeman P, Thomas MA, Chiu T. Lumbar spinal strains associated with whiplash injury: a cadaveric study. Am J Phys Med Rehabil. 2002;;81(9):645-50.

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

Gatterman MI. Whiplash: A patient-centered approach to management. St Louis. Elsevier Mosby. 2012.

Hage R, Detrembleur C, Dierick F, Brismée JM, Roussel N, Pitance L. Sensorimotor performance in acute-subacute non-specific neck pain: a non-randomized prospective clinical trial with intervention. BMC Musculoskelet Disord. 2021 Dec 4;22(1):1017. DOI: 10.1186/s12891-021-04876-4.

Hinoki M. Vertigo due to whiplash injury: A neurotological approach. Acta Otolaryngol Suppl 1984;419:9-29.

Jackson R. The cervical syndrome. Charles C Thomas, Springfield, Illinois. 3e. 1966;131.

MSU. Principles in manual medicine. Reflex activity. Michigan State University. 2017. https://hal.bim.msu.edu/CMEonLine/Autonomic/Sympathetic/ReflexActivity.html

Nederhand MJ, Hermens HJ, IJzerman MJ, Turk DC, Zilvold G. Chronic neck pain disability due to an acute whiplash injury. Pain. 2003 Mar;102(1-2):63-71.

Nijs J, Van Oosterwijck J, De Hertogh W. Rehabilitation of chronic whiplash: treatment of cervical dysfunctions or chronic pain syndrome? Clin Rheumatol. 2009 Mar;28(3):243-51. DOI 10.1007/s10067-008-1083-x.

Nordholf LS. Motor vehicle collision injuries. Biomechanics, diagnosis, and management. Boston. Jones & Bartlett. 2005.

NZCA. What are the Causes of Vertebral Subluxation? (Downloaded October 6, 2022) https://www.nzchiropractors.org/about-chiropractic/vertebral-subluxation.

Parravicini G, Ghiringhelli M. Osteopathic cranial manipulation for a patient with whiplash-associated disorder: a case report. J Chiropr Med. 2021;20(3):163-169.

Sato F. Does spinal alignment influence car occupant responses? The influence of variation in whole spinal alignment patterns on vertebral kinematics under rear impact conditions. Thesis. Division of Vehicle Safety Department of Mechanics and Maritime Sciences Chalmers University of Technology Gothenburg, Sweden 2019

Schafer RC. Basic principles of chiropractic neuroscience. The foundation of clinical practice. 2e. La Grange: ACA Press. 1996;498-500

Schafer RC. General causes and potential effects of the subluxation complex. Chapter 6. IN Basic principles of chiropractic neuroscience. ACA Press. The Chiropractic Resource organization. 1995-2022.

Whiplash-associated disorders [Whiplash-associated disorders]. Schweiz Med Wochenschr. 1999 Sep 25;129(38):1368-80. German. PMID: 10536802.

Siegmund GP. Winkelstein BA, Ivancic PC, et al. The anatomy and biomechanics of acute and chronic whiplash injury. Traffic Inj. Prev., 2009;10(2):101–112.

Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine (Phila Pa 1976). 1995 Apr 15;20(8 Suppl):1S-73S.

Sterling M, Jull G, Vicenzino B, Kenardy J. Characterization of acute whiplash-associated disorders. Spine (Phila Pa 1976). 2004 Jan 15;29(2):182-8.

Storaci R, Manelli A, Schiavone N, Mangia L, Prigione G, Sangiorgi S. Whiplash injury and oculomotor dysfunction: clinical posturographic correlations. Europ Spine J 2006;15(12):1811-1816.

Tanaka N, Atesok K, Nakanishi K, et al. Pathology and treatment of traumatic cervical spine syndrome: whiplash injury. Adv Orthop. 2018 Feb 28;2018:4765050. DOI 10.1155/2018/4765050.

Varatharajan S, Ferguson B, Chrobak K, et al. Are non-invasive interventions effective for the management of headaches associated with neck pain? An update of the Bone and Joint Decade Task Force on Neck Pain and Its Associated Disorders by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. Eur Spine J. 2016 Jul;25(7):1971-99.

Vincent MB. Is a de novo whiplash-associated pain most commonly cervicogenic headache? Cephalalgia. 2008 Jul;28 Suppl 1:32-4.

Wong JJ, Shearer HM, Mior S, et al. Are manual therapies, passive physical modalities, or acupuncture effective for the management of patients with whiplash-associated disorders or neck pain and associated disorders? An update of the Bone and Joint Decade Task Force on Neck Pain and Its Associated Disorders by the OPTIMa collaboration. Spine J. 2016 Dec;16(12):1598-1630.

Woodhouse A, Vasseljen O. Altered motor control patterns in whiplash and chronic neck pain. BMC Musculoskelet Disord. 2008 Jun 20;9:90. DOI 10.1186/1471-2474-9-90. PMID: 18570647; PMCID: PMC2446396.

Woodward MN, Cook JCH, Gargan MF, Bannister GC. Chiropractic treatment of chronic 'whiplash' injuries. Injury. 1996;27(9):643-5.

Other etiological factors

Other factors thought to be etiological or exacerbating factors in a subluxation complex will be covered in later sections of this series. They include biochemical, inflammatory, immune, psychological. Schafer (1998) reveals in great detail the projected etiological factors involved with subluxations. Essentially these are noxious neural sensory irritants which bombard the afferent channels which in turn activate efferent autonomic reflexes. (Sato et al, 1997)

The findings by Sato et al are crystallised as neurological factors as stated by the *New Zealand Chiropractic Association* in noting '*a vertebral subluxation is the impairment of optimal expression of your nervous system caused by physical, biochemical, or psychological dis-stress*'. (NZCA b)

Internal sensory irritants in the form of viscerosomatic reflexes may also be reflected in neural circuits involving spinal segments. Examples may include, irritation from gastric ulcers, bile duct blockage, constipation, kidney stones, indigestion, dyspnoea, inflammation in various organs. (Arendt-Nielsen et al, 2008) (Bath & Owens, 2022)

A gastric viscerovisceral reflex involving for instance a cardiac sphincter spasm would also involve a spinal reflex. (Schafer, 1986; Giamberardino et al, 2010)

Apart from chemical irritants triggering noxious afferent input, electrochemical changes in muscle tissue may also be a factor. There may also be oedema and the inflammatory response in joints activating further sensory afferents. (Zusman, 1986)

The *New Zealand Chiropractic Association* website (NZCA a) lists a number of potential etiological factors:

- Physical (both macro and micro-traumas) such as the birth process, learning to walk, car accidents, accidents at work or home, poor posture (school, work, home), sports injuries, lifting children, prolonged sitting or standing, repetitive activities etc.
- Chemical factors including neurotoxins, excessive alcohol, tobacco, sugar, artificial sweeteners, food colouring, caffeine, MSG, biochemical constituents of foods (eg. grain-fed red meat, hydrogenated fats), environmental toxins (eg. mercury and other heavy metals), lack of proper nutrients (such as essential fatty acids, vitamins, minerals, protein), endocrine changes (for example increased relaxin and oestrogen levels in pregnancy).
- Emotional tensions like chronic stress, family conflict, grief, anxiety, depression etc. These tensions subconsciously influence our posture and neurological tone.

As with most articulations, dysfunctional subluxation may be a consequence of degeneration. Dysfunction would also be a natural consequence of disc degeneration and of arthritic cartilage

degeneration of the vertebral facets. (Lantz, 1988; Kent, 1996; Cramer et al, 2004; Colloca et al, 2012)

Extended reference compilation

Other etiological factors

Arendt-Nielsen L, Schipper KP, Dimcevski G, Sumikura H, Krarup AL, Giamberardino MA, Drewes AM. Viscero-somatic reflexes in referred pain areas evoked by capsaicin stimulation of the human gut. Eur J Pain. 2008 Jul;12(5):544-51.

Bath M, Owens J. Physiology, viscerosomatic reflexes. StatPearls [Internet] 2022. https://www.ncbi.nlm.nih.gov/books/NBK559218/

Colloca CJ, Gunzburg R, Freeman BJ, Szpalski M, Afifi M, Moore RJ. Biomechancial quantification of pathologic manipulable spinal lesions: an in vivo ovine model of spondylolysis and intervertebral disc degeneration. J Manipulative Physiol Ther. 2012 Jun;35(5):354-66.

Cramer GD, Fournier JT, Henderson CN, Wolcott CC. Degenerative changes following spinal fixation in a small animal model. J Manipulative Physiol Ther. 2004 Mar-Apr;27(3):141-54. DOI 10.1016/j.jmpt.2003.12.025. PMID: 15129196.

Giamberardino MA, Costantini R, Affaitati G, Fabrizio A, Lapenna D, Tafuri E, Mezzetti A. Viscero-visceral hyperalgesia: characterization in different clinical models. Pain. 2010 Nov;151(2):307-322.

Kent C, Vernon LF. Vertebral subluxation. In: Case series in chiropractic MRI. Arlington: International Chiropractic Assoc. 1998;11-26.

Lantz CA. Immobilisation degeneration and fixation hypothesis of chiropractic subluxation. Chiropr Research J. 1988;1(1):21-46.

NZCA (a) What are the Causes of Vertebral Subluxation? (Downloaded October 6, 2022) https://www.nzchiropractors.org/about-chiropractic/vertebral-subluxation.

NZCA (b), New Zealand Chiropractic Association https://www.chiropractic.org.nz/about-chiropractic/vertebral-subluxation/.

Sato A, Sato Y, Schmidt RF. The impact of somatosensory input on autonomic functions. In: Reviews of Physiology Biochemistry and Pharmacology.

Blaustein MP, Grunicke H, Pette D, Schultz G. Schweiger M, Habermann M, editors: Berlin Springer-Verlag, 1997;130, 328pps.

Schafer RC. Basic spinal subluxation considerations. Chapter 18. In" Chiropractic management of sports and recreational injuries. 2nd edn. Williams & Wilkins. 1986. https://chiro.org/ACAPress/Basic_Spinal_Subluxation_Considerations.html

Zusman, M. Spinal Manipulative therapy: review of some proposed mechanisms, and a new hypothesis. Aust J Physioth. 1986;32(2):89-99.

Vertebral displacement - biomechanical

Facet displacement/translation

Biomechanical vertebral displacement and Facet displacement/translation are one element of a vertebral subluxation complex

Facet translation takes place during physiological motion. However, associated articular fixation or locking of the facet positions the facet within its normal range, but not necessarily in its central neutral position. (Bolton & Holland, 2000; Budgell & Bolton, 2010; Muggleton & Allen, 1998)

We would submit that biophysics alone would preclude articular displacement without a degree of articular fixation, otherwise the segments would experience aberrant motion. Consequently, dysfunctional fixation or aberrant motion would be associated with noxious sensory and autonomic reflex activation as key elements of the VSC. (Jinkins et al, 1989; Pickar, 2002; King et al, 2011; Bigland et al, 2013)

The term vertebral translation implies an osseous displacement. Many papers seemed to focus on this mechanical aspect without consideration of the sensory influence. However, all elements involved in such a structural disturbance should be considered, especially of physiological function, sensory, vascular effects, and their ramifications. (Boal & Gillette, 2004; Pickar & Bolton, 2012; Ohtori et al, 2016)

Wu et al also noted that segmental translation associated with instability due to disc injury can be measured and cases of dysfunction in functional x-ray studies of symptomatic and asymptomatic patients. (Cornu et al, 1997; Wu et al, 2015)

Vertebral displacement

C1/C2 displacement of 4.5mm on lateral functional views is indicative of instability according to Pathria et al. (1991) We suggest that displacement less than this, particularly when associated with clinical signs and symptoms, can also be indicative of a need to address by manipulation.

These displacements may also be indicated by indications of widening interspinous space, widening of the facet joint, focal kyphotic angulation and greater than 3 mm of anterior displacement. (Kivacs, 1995; Pathria, 1991)

In clarification, it must be noted that traditional medical use of the term subluxation essentially refers to joint displacements that are less than a luxation (dislocation); Parker used the term mildly displaced, a form of minimal displacement of facets. These terms imply just the osseous element to be differentiated from the chiropractic model of the complex, which although it comprises articular disturbance, also incorporates neurological sensory receptors and other anatomical elements including ligaments and particularly the vertebral articulations. (Parker, 2020)

As biomechanical lesions, subluxations seem to have traditionally been considered of lesser consequence than frank pathology and fracture and may not therefore have been routinely reported. However, the association of activated autonomic reflexes suggest further pathophysiological ramifications. Inherent in this discussion of mechanical elements, is the degree of physiological change involved in any disruption and the type of associated symptoms and signs. Pure fixation within the normal ROM is unlikely to generate soft tissue damage but could activate noxious sensory changes.

In 1996, Nuñez et al reported that 36.4% of cervical spine plain films '*had*' fractures (n = 50) that were not revealed or were incompletely demonstrated on radiography; '*one third*' of these were clinically significant. Similarly, radiological examination can be a partial aid in diagnosing and assessing suitability for manipulative care and determining the therapeutic approach for a particular condition or an appropriate referral. (See also Radiology and the Subluxation) (Nuñez et al, 1996; Berlin, 2003)

Segmental alignment and alleviation of neck pain symptoms were correlated in a study by Rochester in 2009. He concluded that the data supported the alignment model's predictive validity of disability outcome. Further, Manchikanta et al noted that the articular facets are the primary source of neck pain in 54%-60% of whiplash patients. (Rochester, 2009; Manchikanti et al, 2002)

White and Panjabi state that anterior displacement of cervical vertebral bodies of 3.5mm is a sign of instability. Green indicates that up to 1 – 3mm is within normal limits, while Scher noted 1mm. It is suggested here that symptomatic displacement of less than that can be a significant part of a patient's condition, and the reason for them seeking care and one of the justifications for radiological examination. This is not to say that displacement of less than this is likely to be asymptomatic due to facet dysfunction. Again, it is the disturbance, signs and symptoms that indicate a need for addressing the patient's presenting condition. (White et al, 1975; Green et al, 1981; Scher, 1979)

Penning noted a deviation from the normal smooth convexity where a '*minor displacement*' or '*step formation*' may be characteristic in the flexed cervical spine, but not in the neutral position. (Penning, 1964) It is suggested that the stair step formation may also be found on neutral lateral

cervical views and may be indicative of a hyperflexion injury, instability or vertebral dysfunctional subluxation.

It is asserted here that minor displacements, even up to 1mm which are evident on plain film in the neutral posture and which are suspected to be associated with particular symptoms, probably are the vertebrogenic factor. Further, that finding is likely to be exaggerated on functional views. Braakman and Penning, and Dvorak all stress caution with functional views for recent injuries, a natural precaution until the extent of any neural compromise and the degree of instability is determined. (Dvorak et al, 1987; Braakman & Penning, 1971)

In 1990 in relation to vertebral stability, Daffner and colleagues recognised a number of the radiological findings alluded to in this presentation – albeit as a matter of degree with other associated signs and symptoms. (Daffner, 1990) They are:-

- Vertebral displacement
- Widening of the facet interspace
- Widening of the interlaminar space
- Disruption of the symmetry of the posterior vertebral body line (sagittal view)

Green and colleagues also note an increased distance between the posterior cortex of the '*subluxated vertebra*' and the superior facets of the subjacent vertebra. They noted further the anterior-superior displacement of the inferior facets of the suprajacent vertebra in anterior subluxation in relation to the subjacent segment. (Green et al, 1981)

The radiologist Hadley, (1976) formally recognised the articular subluxation as early as 1936. Forty years later this esteemed radiologist went further in his text when he recognised the mechanical disruption of vertebrae by adopting such terms as:

- Bilateral forward subluxation (incomplete dislocation) (p. 127)
- Subluxations (partial displacement) of the vertebral bodies (p. 128)
- Forward tipping (p. 127)
- Spinous processes are separated (p. 127)
- Displacement of the articular surfaces. (p. 130)
- Lateral displacement (p. 130)

In 1981 Green et al noted possible postural kyphotic changes with muscle and ligamentous damage as a result of a hyeprflexion cervical sprain with segmental anterior subluxation and a 20% chance of segmental instability. They also noted the possibility of a wedge fracture of the vertebral body. They did not acknowledge sensory or other neurological changes but did note:

1. a localised kyphotic angulation at the level of injury
2. anterior rotation, or displacement, of the subluxed vertebra
3. anterior narrowing and posterior widening of the disc space
4. widening of the space between the subluxed vertebral body and the subjacent articular masses
5. displacement of the inferior articulating facets of the subluxed vertebra with respect to their contiguous subjacent facets, and
6. widening of the interspinous space ('fanning'). (Green et al, 1981)

Despite the plethora of studies regarding displacement, there seems to be a marked absence of consideration of the sensory activation that would be associated with such a disturbance.

Differentiating vertebral body and facet displacement

Clarification is needed to differentiate the radiological observable displacement of intervertebral facets and displacement of the vertebral body. This discourse is considering anterior, posterior or lateral displacement of vertebral bodies below C2. Vertebral segments may undergo functional changes of rotation, lateral tilting as well as anterior and posterior tilting within their physiological range of motion, particularly noticeable through motion palpation and other palpatory indicators. These may be regarded as more typical subluxations. However lineal vertebral body anterior, posterior, or lateral displacement is a form of vertebral listhesis or vertebral body translation usually involving the whole segment; except in cases of pars interarticularis separation when the vertebral body and posterior elements can be separated. Such listheses may be arguably sub-luxated as they are seen as outside the physiological range of motion.

Above C2, the atlas (C1) segment may translate lineally in toto within its normal range. As with the occipital condyles in relation to C1 and the C1 relationship with C2 the consideration of all spinal segments here is related to interarticular facet function and positioning within their physiological range of motion.

Stochkendahl and Christensen recognised in 2010 biomechanical disturbance of thoracic articulations by stating '*Several overlapping conditions and syndromes of focal disorders, including Tietze syndrome, costochondritis, chest wall syndrome, muscle tenderness, slipping rib, cervical angina, and segmental dysfunction of the cervical and thoracic spine, have been reported to cause pain*.' These conditions are recognised as Germanovich and Ferrante concluded that '*Pain physicians should learn certain basic manual manipulation skills both for diagnostic and therapeutic purposes*.' However, this does not appear to have become a routine medical intervention although a hooking manoeuvre has been recommended by Foley and Cassidy. (Scott & Scott, 1993; Kumar et al, 2013; Germanovich & Ferrante, 2016; Foley et al, 2019, 2021)

Olisthesis

Braakman and Penning coined the term *olisthesis* in 1971. They claim this overall term is intended to '*describe a pathological relationship between the vertebral bodies C2 to T1 with preservation of normal relationships within the intervertebral joints.*' Although there is no further definition, it is discussed with the terms retrolisthesis, anterolisthesis and spondylolisthesis. (Braakman & Penning, 1971)

Extended reference compilation

Vertebral displacement

Berlin L. CT versus radiography for initial evaluation of cervical spine trauma: what is the standard of care? Am J Roentg. 2003;180(4):911-915. DOI 10.2214/ajr.180.4.1800911

Bigland MJ, Budgell BS, Bolton PS. The influence of cervical spinal cord compression and vertebral displacement on somatosympathetic reflexes in the rat. Spine J. 2015;15(6):1310-7. DOI 10.1016/j.spinee.2013.08.013.

Boal RW, Gillette RG. Central neuronal plasticity, low back pain and spinal manipulative therapy. J Manipulative Physiol Ther. 2004 Jun;27(5):314-26. DOI 10.1016/j.jmpt.2004.04.005.

Bolton PS, Holland CT. Afferent signalling of vertebral displacement in the neck of the cat. Soc Neurosci Abstr 1996;22:1802. (Cited in: Bolton PS. Reflex effects of vertebral subluxations: The peripheral nervous system. An update. J Manipulative Physiol Ther 2000;23(2):101-103.

Braakman R, Penning L. Injuries of the cervical spine Excerpta Medica. 1971:47-48.

Budgell BS, Bolton PS. Cerebrospinal fluid pressure response to upper cervical vertebral motion and displacement in the anesthetised rat. J Manipulative Physiol Ther. 2010;33(5):355-361.

Cornu JY, Gangloff S, Guyot J. Instability and manipulation. J Orthop Med. 1997;19(1).10-14.

Daffner RH, Deeb ZL, Goldberg AL, et al. The radiological assessment of post-traumatic vertebral stability. Skelet Radiol. 1990;1((2):103-8.

Dvorak J, Panjabi M, Gerber M, Wichmann W. CT-functional diagnostics of the rotatory instability of upper cervical spine, 1: an experimental study on cadavers. Spine. 1987;12:197–205.

Foley CM, Sugimoto D, Mooney DP, Meehan WP 3rd, Stracciolini A. Diagnosis and Treatment of Slipping Rib Syndrome. Clin J Sport Med. 2019;29(1):18-23. DOI 10.1097/JSM.0000000000000506.

Foley D, Cassidy M. A Clinical Review of Slipping Rib Syndrome. Curr Sports Med Rep. 2021;20(3):164-168. dDOI 10.1249/JSR.0000000000000821.

Germanovich A, Ferrante FM. Multi-Modal Treatment Approach to Painful Rib Syndrome: Case Series and Review of the Literature. Pain Physician. 2016 Mar;19(3):E465-71. 27008303.

Green JD, Harle TS, Harris JH. Anterior subluxation of the cervical spine: hyperflexion sprain. Am J Neuroradiol (AJNR). 1981;2(3):243-50. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8331500/

Hadley LA. Anatomico-roentgenographic studies of the spine. Springfield. Charles C Thomas.1976; 132, 151,152.

Jinkins JR, Whittemore AR, Bradley WG. The anatomic basis of vertebrogenic pain and the autonomic syndrome associated with lumbar disk extrusion. AJR Am J Roentgenol. 1989 Jun;152(6):1277-89. DOI 10.2214/ajr.152.6.1277.

King HH, Patterson MM. Clinical applications and manual therapy on physiologic functions and systemic disorders; evidence base and implications for research. In: King HH, Janig W, Patterson MM. The science and clinical application of manual therapy. Churchill Livingstone, Edinburgh. 2011;301-312.

Kovacs A. Subluxation and deformation of the cervical apophyseal joints. Acta Radiologica Jan 1955;43:1-16.

Kumar R, Ganghi R, Rana V, Bose M. The painful rib syndrome. Indian J Anaesth. 2013;57(3):311-3. DOI 10.4103/0019-5049.115585.

Manchikanti L, Singh V, Rivera J, Pampati V. Prevalence of cervical facet joint pain in chronic neck pain. Pain Physic 2002;5(3):243-9.

McGregor M, Mior S. Anatomical and functional perspectives of the cervical spine: Part I: the normal: cervical spine. J Canad Chiropr Assoc. 1989;33(3):123-9.

Muggleton JM, Allen R. Insights into the measurement of vertebral translation in the sagittal plane. Med Engineer Phys. 1998;20(1):21-32.

Murtagh J, Rosenblatt J. Murtagh's General Practice. 5e. North Ryde, McGraw Hill. 2011.

Nuñez DB Jr, Zuluaga A, Fuentes-Bernardo DA, Rivas LA, Becerra JL. Cervical spine trauma: how much more do we learn by routinely using helical CT? RadioGraphics. 1996; 16:1307-18.

Ohtori S, Miyagi M, Inoue G. Sensory nerve ingrowth, cytokines, and instability of discogenic low back pain: A review. Spine Surg Relat Res. 2018 Jan 27;2(1):11-17. DOI 10.22603/ssrr.2016-0018.

Parker L. (MD) Causes of lumbar facet disorders. Spine Health. June 24, 2020 https://www.spine-health.com/conditions/arthritis/causes-lumbar-facet-joint-disorders

Pathria MN, Petersilge CA. Spinal trauma. Radiol Clinics North Am. 1991;29(4):847-65.

Penning L. Nonpathologic and pathologic relationships between the lower cervical vertebrae. Am J Radiol Rad Therapy Nuc Med 1964;91(5):1036-1050.

Penning L. Normal movements of the cervical spine. Am J Roentgenol 1978;130:317-26. https://www.ajronline.org/doi/pdf/10.2214/ajr.130.2.317.

Pickar JG. Neurophysiological effects of spinal manipulation. Spine J. 2002 Sep-Oct;2(5):357-71. DOI 10.1016/s1529-9430(02)00400-x.

Pickar JG, Bolton PS. Spinal manipulative therapy and somatosensory activation. J Electromyogr Kinesiol. 2012 Oct;22(5):785-94. DOI 10.1016/j.jelekin.2012.01.015. Epub 2012 Feb 19.

Rochester RP. Neck pain and disability outcomes following chiropractic upper cervical care: a retrospective case series. J Canad Chiropr Assoc. 2009;53(3):173-85.

Scher AT. Anterior cervical subluxation: an unstable position. Am J Roentg 1979;133:275-80.

Scott EM, Scott BB. Painful rib syndrome--a review of 76 cases. Gut. 1993 Jul;34(7):1006-8. DOI 10.1136/gut.34.7.1006.

Shivachev Y, Dimitrov A. Chiropractic as a system of manual techniques. Varna Medical Forum. 2021;10(2):133-136. DOI: http://dx.doi.org/10.14748/vmf.v10i2.7890 https://journals.mu-varna.bg/index.php/vmf/article/view/7890.. (English abstract)

Stochkendahl MJ, Christensen HW. Chest pain in focal musculoskeletal disorders. Med Clin North Am. 2010 Mar;94(2):259-73. DOI 10.1016/j.mcna.2010.01.007.

White AA, Johnson RM, Panjabi MM, Southwick WO. Biomechanical analysis of clinical; stability in the cervical spine. Clin Orthop Rel Res. 1975;109:85-96.

Wu AK, Jou JY, Lee HM, et al. The reproducibility comparison of two intervertebral translation measurements in cervical flexion-extension. The Spine J. 2015;15(5):1083-91.

Xie R, Liang L, Li K. et al. Effects of seated lumbar rotation manipulation in treating degenerative lumbar instability: a protocol for a randomized controlled trial. Trials. 2021;22, 398. https://doi.org/10.1186/s13063-021-05350-1.

Vertebral function and dysfunction

Articular dysfunction

It is suggested that the ideal spine is one that is physiologically mobile, flexible, and supple, with each vertebral segment moving freely and independently within its normal range of motion. As such, abnormal segmental function would be recognised. It is the appreciation of dysfunction as a clinical feature that becomes significant and a key feature in this manual field. (Penning, 1978; McGregor & Mior, 1989; Xie et al, 2021; Shivacjev & Dimitrov, 2021)

Murtagh and Rosenblatt emphasised biomechanical disruption of vertebrae as spinal dysfunction. They recognised a neurological element as a possible neurological differential in a range of conditions. They also state that at times '*Spinal or vertebral dysfunction can be regarded as a masquerade mainly because the importance of the spine as a source of various pain syndromes has not been emphasised in medical training*.' (Murtagh et al, 2011)

For altered sensory input from a vertebra to be activated at a noxious level, there would be biomechanical segmental disturbance. This is the case with any somatic disturbance which stimulates the usual sensory homeostatic feedback. (Maigne & Vautravers, 2003)

As recently as 2022, while medicine and physiotherapy have adopted many of the chiropractic and osteopathic concepts after decades of resistance, there appears to be an enigmatic element from an evidence-base viewpoint in relation to vertebral dysfunction. The concepts seem to have compiled a strong evidence base founded on clinical observations and positive outcomes. (Schnell et al, 2022)

Vertebral dysfunction

Once physiological range of motion is compromised, it may be termed '*dysfunction*', and particularly so if it is associated with signs and symptoms. As a diagnostic sign, identification of segmental dysfunction has become a significant part of spinal assessment, diagnosis, and analysis in mainstream chiropractic and other professions. This is usually a part of the physical examination, but may also be diagnostic with functional radiological studies, typically the Davis Series of the cervical spine. (Betge, 1977; Sherman & Bauer, 1982; Raza et al, 2013)

The principal purpose of manipulation is to increase the range of motion in restricted spinal segments, which in turn is believed to help improve nutrition, gate pain, increase tolerance to insult, and improve function. Interestingly, Paris did not include neural or vascular disturbances here. (Paris, 1996)

Since recognised by Gillet (1963) and Faye (1983) other manual professions have adopted motion to assess segmental vertebral motion and hyper and hypo spinal mobility. Motion palpation is a form of dynamic assessment of the functional integrity of a segment's motion. It was initiated by Gillet in the 1930s. (Faulkner et al, 2021) This appears to be the origin for determining and analysing articular dysfunction as practised by chiropractors for about 90 years. It is also used by osteopaths and been adopted by physiotherapists. (Gillet, 1963; Johnston, 1975; Faye, 1983; Alley 1983; Nyberg & Smith 2013; Senzon 2018; Faulkner et al 2021)

Articular dysfunction may take the form or be determined by a range of altered motions from the normal physiology for a particular articulation. Motion palpation is one of the assessment

examinations methods. (Snodgrass et al, 2008; Landel et al. 2008; Passmore & Descarraeaux. 2012; Nyberg et al 2013; Cooperstein & Young, 2016; Hervey & Byfield 1991, Pagé et al, 2018)

Finneson (1980a)stated that '*facet dysfunction may occur from derangement and instability of the facet joint*.'

Deviation from normal segmental motion in the form of functional articular disruption of normal joint physiology, such altered mobility may be regarded as vertebral dysfunction. It is the activation of noxious sensory afference that associated autonomic reflex efference that is considered critical here. It may present in any of the following primary forms:-

- Hypomobility
- Fixation
- Aberrant motion
- Hypermobility/instability
- Changes in joint play
- In association with articular displacement.
- In association with an inflammatory response
- In association with degenerative change

It would seem that the effects of the degrees and types of altered sensory input has yet to be made. (Sato et al, 1997) Some activation may well be hyper and others hypo. The assessment seems to be currently based on clinical presentation as signs and symptoms.

The recognition in the literature of normal ranges of spinal motion as in physiological function, highlights the role of dysfunction as a diagnostic clinical sign whether it is obtained by observation, palpation, radiologically, or all three.

In 2008 Kirpalani and Mitra, and others appear to consider '*radiofrequency neurotomy as the key (medical) avenue to alleviate pain associated with cervical facet joint dysfunction*'. So rather than restore the more normal mechanical function, the nerve block is aimed at stopping the pain which can be the result of a particular disturbed facet(s) which s potentially the cause of certain cervicogenic symptoms. (Kirpalani & Mitra, 2008; Lawson et al, 2020)

Extended reference compilation

Vertebral function and dysfunction

Abbott JH, Fritz JM, McCane B, et al. Lumbar segmental mobility disorders: comparison of two methods of defining abnormal displacement kinematics in a cohort of patients with non-specific mechanical low back pain. BMC Musculoskeletal Disorders. 2006;7:45. DOI 10.1186/1471-2474-7-45.

Azizi S, Rezasoltani Z, Najfi S, et al. The relationship between dorsal spine dysfunction and gastrointestinal pain and efficacy of manipulation of them. Phys Med Rehab Electrodiag. 2020;2(1):2-6.

Beck RW. Functional neurology for the practitioners of manual therapy. Edinburgh. Churchill Livingstone. 2008. Subluxation dysfunction p 9 chapter 1, ch 3 p65.

Beneck GJ, Kulig K, Landel RF, Powers CM. The relationship between lumbar segmental motion and pain response produced by a posterior-to-anterior force in persons with nonspecific low back pain. J Orthop Sports Phys Ther. 2005 Apr;35(4):203-9.

Betge G. The value of cineradiographic motion studies in the diagnosis of dysfunctions of the cervical spine. Bull Eur Chiro Union. 1977;25:20-7.

Bifulco P, Cesarelli M, Romano M,et al. Measurement of intervertebral cervical motion by means of dynamic x-ray image processing and data interpolation. Int J Biomed Imaging. 2013;2013:152920. DOI 10.1155/2013/152920.

Bogduk N, Mercer S. Biomechanics of the cervical spine. 1 Normal kinematics. Clin Biomech. (Bristol, Avon). 2000;15(9):633-648. https://asset-pdf.scinapse.io/prod/2169681823/2169681823.pdf online Funct & dysfunct

Cassidy JD, Quon JA, LaFrance LJ, et al. The effect of manipulation on pain and range of motion in the cervical spine: a pilot study. J Manipulative Physiol Ther. 1992 Oct;15(8):495-500. Erratum in: J Manipulative Physiol Ther 1992 Nov-Dec;15(9). PMID: 1402409.

Charlton KH. Normal neck motion. Thesis. University of Queensland, School of Medicine. 31st Dec. 2007. https://espace.library.uq.edu.au/data/UQ_370653/s4044909_phd_submission.pdf.

Dewitte V, Cagnie B, Barbe T, et al. Articular dysfunction patterns in patients with mechanical low back pain" a clinical algorithm to guide specific mobilisation and manipulation techniques. Man Ther. 2015;20(3):499-502. https://doi.org/10.1016/j.math.2014.11.006.

Dvorak J, Panjabi M, Gerber M, Wichmann W. CT-functional diagnostics of the rotatory instability of upper cervical spine, 1: an experimental study on cadavers. Spine. 1987;12:197–205.

Faulkner TJ, Foley J, Hynes RJR. The origins of fixation theory in chiropractic: does credit go to Dr. Oakley Smith or Dr. Henri Gillet? Chiropr Hist. 2021-2022;41(2):39-44.

Finneson BE. Low back pain.2e. Philadelphia: JB Lippincott Co.1980;563.

Fritz JM, Whitman IM, Childs JD. Lumbar segment mobility assessment: an examination of validity for determining intervention strategies in patients with low back pain. Arch Phys Med Rehab. 2005;86(9):1745-52.

Goodley PH. Release from pain. essentials of orthopaedic medicine. 2e. 2012:8. https://www.drgoodley.com/book.html.

Hino H, Abumi K, Kanayama M, Kaneda K. Dynamic motion analysis of normal and unstable cervical spines using cineradiography. An in vivo study. Spine (Phila Pa 1976). 1999 Jan 15;24(2):163-8. DOI 10.1097/00007632-199901150-00018.

Humphreys BK, Delahaye M, Peterson CK. An investigation into the validity of cervical spine motion palpation using subjects with congenital block vertebrae as a 'gold standard'. BMC Musculoskelet Disord. 2004;5:19. DOI 10.1186/1471-2474-5-19.

Kirpalani D, Mitra R. Cervical joint dysfunction: a review. Arch Phys Med Rehabil 2008;89:770-774.

Kulig K, Powers CM, Landel RF, et al. Segmental lumbar mobility in individuals with low back pain: in vivo assessment during manual and self-imposed motion using dynamic MRI. BMC Musculoskelet Disord. 2007:29;8:8. DOI 10.1186/1471-2474-8-8. PMID: 17261197; PMCID: PMC1794409.

Lawson GE, Nolet PS, Little AR, et al. Medial branch for diagnosis of facet joint pain etiology and use in chronic pain litigation. Int J Environ Res Public Health. 2020 Oct 29;17(21):7932. DOI 10.3390/ijerph17217932.

Lehman GJ. Biomechanical assessments of lumbar spinal function. How low back pain sufferers differ from normal. Implications for outcome measures research. Part I: kinematic assessments of lumbar function. J Manipulative Physiol Ther. 2004;27(1):57-62. DOI 10.1016/j.jmpt.2003.11.007.

Leung, S. The value of cineradiographic motion studies in the diagnosis of dysfunctions of the cervical spine. Bull Eur Chiro Union 1977;25(2):28-43.

Lundberg G, Gerdle B. The relationship between spinal sagittal configuration, joint mobility, general low back mobility and sagittal mobility in female homecare personnel. Scand J Regab Med. 1999;31:197-206.

MacDonald RS. Primary dysfunction of the spine. J Interprofessional Care. 1988;3:27-33.

McGregor M, Mior S. Anatomical and functional perspectives of the cervical spine: Part I: the normal: cervical spine. J Canad Chiropr Assoc. 1989;33(3):123-9.

Meloche JP, Bergeron Y, Bellavance A, et al. Painful intervertebral dysfunction: Robert Maigne's original contribution to headache of cervical origin. The Quebec Headache Study Group. Headache. 1993;33(6):328-34.

Mennell JM. The validation of the diagnosis "joint dysfunction" in the synovial joints of the cervical spine. J Manipulative Physiol Ther. 1990 Jan;13(1):7-12. PMID: 2324662.

Murtagh J, Rosenblatt J. Murtagh's General Practice. 5th edn. North Ryde, McGraw Hill. 2011;222.

Nelson KE, Glonek T. Somatic dysfunction in osteopathic family medicine. Philadelphia, Lippincott Williams & Wilkins. 2014.

Nim CG, Kawchuk G, Schiøttz-Christensen B, O'Neill S. The effect of clinical outcomes when targeting spinal manipulation at stiffness or pain sensitivity: a randomized trial. Sci Rep, 2020;10:14615. https://doi.org/10.1038/s41598-020-71557-y.

Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. J Spinal Disord. 1992;5:383-9.

Parera CE. Radiological evaluation of the function of the cervical spine. Acta Radiol 1975: Suppl 347.

Passias PG, Wang S, Kozanek M, et al. Segmental lumbar rotation in patients with discogenic low back pain during functional weight-bearing activities. J Bone Joint Surg Am. 2011;93(1):29-37.

Penning L. Kinematics of cervical spine injury: a functional radiological hypothesis. Eur Spine J. 1995;4:126-32.

Penning L. Normal movements of the cervical spine. Am J Roentgenol 1978;130:317-26. https://www.ajronline.org/doi/pdf/10.2214/ajr.130.2.317.

Physiopedia. Spinal manipulation. https://www.physio-pedia.com/Spinal_Manipulation

Raza M, Elkhodair S, Zaheer A, Yousaf S. Safe cervical spine clearance in adult obtunded blunt trauma patients on the basis of a normal multidetector CT scan--a meta-analysis and cohort study. Injury. 2013 Nov;44(11):1589-95.

Schnell H, Wagner FM, Locher H. Die segmentale und somatische Dysfunktion : Wie funktioniert Manuelle Medizin? [Segmental and somatic dysfunction: How does manual medicine work?]. Orthopade. 2022 Apr;51(4):253-262. German.

Sherman R, Bauer F. X-ray x-pertise – from A to X. Parker Chiropractic Research Foundation. Fort Worth. 1982.

Swartz EE, Floyd RT, Cendoma M. Cervical spine functional anatomy and the biomechanics of injury due to compressive loading. J Athl Train. 2005 Jul-Sep;40(3):155-61.

Taylor JAM. The role of radiography in evaluating subluxation. In: Gatterman MI. Foundations of chiropractic subluxation. St Louis, Elsevier Mosby. 2e. 2005;115-32.

Vernon H, Steiman I, Hagino C. Cervicogenic dysfunction in muscle contraction headache and migraine: a descriptive study. J Manipulative Physiol Ther. 1992;15(7):418-29.

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

Vikne H, Bakke ES, Liestel K, Engen SR, Vollestad N.Muscle activity and head kinematics in unconstrained movements in subjects with chronic neck pain; cervical motor dysfunction or low exertion motor output? BMC Musculoskeletal Disorders 2013, 14:34.

Whitman JM, Childs JD. Lumbar spine segmental mobility assessment: an examination of validity for determining intervention strategies in patients with low back pain. Arch Phys Med Rehab. 2005;86(9):1745-52

Yeomans SG. The assessment of cervical intersegmental mobility before and after spinal manipulative therapy. J Manipulative Physiol Ther. 1992 Feb;15(2):106-14. PMID: 1564406.

Segmental dysfunction

Hypermobility, Segmental Instability

As noted under '*Whiplash*', segmental hypermobility or hypermobile subluxation is a relatively common clinical finding in the manipulative sciences. It is however, managed quite differently to fixations and hypomobilities. (Bourdillon & Day, 1987; McGregor & Mior, 1989, 1990; Gatterman, 2005, 2012)

Segmental hypermobility is also listed as instability and insufficiency, and inefficiency. A significant discussion on segmental hypermobility has been provided in the translated reference text by Schmörl and Junghanns. (1971a)

Segmental hypermobility is steadily becoming more widely recognised medically. (Sihvonen & Partanen, 1990; Kulig et al, 2007; Goode et al 2019)

When the COR (Centre of Rotation) deviated from its normal location, spinal motion ability and stability were sensitive to the variation in different directions. (Kuai et al, 2019)

Hypermobility is not necessarily a contraindication to manipulation as such. However, management of the condition would be quite different. Manual procedures may be judiciously conducted in appropriate cases but directed at compensatory restricted regions so that mobility may be reduced in the unstable segment and distributed over a greater region. Stabilising exercises would also be indicated, or temporary bracing. Naturally care must be taken with hypermobile articulation, particularly if Ehlers-Danlos Syndromes (EDS) are suspected. (Strunk et al, 2014; Sarker et al, 2017; Boudreau et al, 2020)

It may be noted that depending on the degree of segmental instability that manipulation may still be conducted, but not at that level. (Borody, 2004) Judicious assessment may find compensatory subluxations at other segmental levels which tend to exaggerate the instability. As such release of compensatory fixations by sagacious technique selection applied to other levels

may ease the mechanical focal strain at the unstable level and relieve symptoms. Other measures may also need to be implemented such as specific corrective (isometric) exercises, activity advice, postural advice. There is evidence however, of manipulation of such unstable segments. (Xie et al, 2021; Gatterman ,2005 (d))

'*Significant dysautonomia is observed in patients with Joint Hypermobility Syndrome. Symptoms related to the autonomic nervous system, such as syncope and presyncope, orthostatic intolerance, palpitations, chest discomfort, fatigue, and heat intolerance, are significantly more common among hypermobile patients.*' (Eccles et al, 2015)

One of the recommendations for joint hypermobility as noted by the NHS is to '*correct the movement of individual joints.*' (National Health Service, 2023)

Extended reference compilation

Functional Vertebral Hypermobility

Borody C. Neck-tongue syndrome. J Manipulative Physiol Ther. 2004 Jun;27(5):e8. doi: 10.1016/j.jmpt.2004.04.010. PMID: 15195046.

Boudreau PA, Steiman I, Mior S. Clinical management of benign joint hypermobility syndrome: a case series. J Can Chiropr Assoc. 2020 Apr;64(1):43-54. PMID: 32476667; PMCID: PMC7250515.

Bourdillon JF, Day EA. Spinal manipulation. Norwalk:Heinemann, 1988:237.

Eccles JA, Owens AP, Mathias CJ, Umeda S, Critchley HD. Neurovisceral phenotypes in the expression of psychiatric symptoms. Front Neurosci. 2015;9:4. doi: 10.3389/fnins.2015.00004. PMID: 25713509; PMCID: PMC4322642.

Gatterman MI. Whiplash: A patient-centered approach to management. St Louis. Elsevier Mosby. 2012:139-40 (d), 266-73.

Gazit Y, Nahir AM, Grahame R, Jacob G. Dysautonomia in the joint hypermobility syndrome. Am J Med. 2003 Jul;115(1):33-40. doi: 10.1016/s0002-9343(03)00235-3. PMID: 12867232.

Goode AP. Cleveland RJ, Schwartz TA. et al. Relationship of joint hypermobility with low back pain and lumbar spine osteoarthritis. BMC Musculoskelet Disord, 2019;20;158. https://doi.org/10.1186/s12891-019-2523-2.

Hakim AJ, Grahame R. Non-musculoskeletal symptoms in joint hypermobility syndrome. Indirect evidence for autonomic dysfunction? Rheumatology. 2004;43(9):1196-5.

Kuai S, Guan X, Li Y, et al. Influence of deviated centres of rotation on kinematics and kinetics of a lumbar functional unit: an in vitro study. Med Sci Monit. 2019;25:4751-8.

Kulig K, Landel R, Powers CM. Assessment of lumbar spine kinematics using dynamic MRI: a proposed mechanism of sagittal plane motion induced by manual posterior-to-anterior mobilization. J Orthop Sports Phys Ther. 2004;34:57-64. https://www.jospt.org/doi/abs/10.2519/jospt.2004.34.2.57.

McGregor M, Mior S. Anatomical and functional perspectives of the cervical spine: Part I: The normal: cervical spine. J Canad Chiropr Assoc. 1989;33(3):123-9/

McGregor M, Mior S. Anatomical and functional perspectives of the cervical spine: Part II The: "unstable" cervical spine. J Can Chiropr Assoc. 1990;34(3):145-52.

NHS Joint hypermobility NHS Inform,(Downloaded Jan 22, 2023). https://www.nhsinform.scot/illnesses-and-conditions/muscle-bone-and-joints/conditions/joint-hypermobility

Peterson CK, Gatterman MI. The nonmanipulatable subluxation. In: Gatterman MI. Foundations of chiropractic subluxation. St Louis, Elsevier Mosby. 2nd edn 2005;168-190,.

Sarker KK, Sethi J, Mohanty U. Effect of spinal manipulation on specific changes in segmental instability, pain sensitivity and heal-related quality of life among patients with chronic non-specific low back pain – a randomized clinical trial. Ann Res Rev Biol. 2017;18(2):1-10.

Schmörl G, Junghanns H. Inefficient motor segment (Intervertebral insufficiency). In: The human spine in health and disease. New York. Grune & Stratton. 2nd US edn. 1971:213-229

Sihvonen T, Partanen J. Segmental hypermobility in lumbar spine and entrapment of dorsal rami. Electromyogr Clin Neurophysiol. 1990 Apr-May;30(3):175-80.

Strunk RG, Pfefer MT, Dube D. Multimodal chiropractic care of pain and disability for a patient diagnosed with benign joint hypermobility syndrome: a case report. J Chiropr Med. 2014 Mar;13(1):35-42. doi: 10.1016/j.jcm.2014.01.009. PMID: 24711783; PMCID: PMC3976499.

Xie, R., Liang, L., Li, K. et al. Effects of seated lumbar rotation manipulation in treating degenerative lumbar instability: a protocol for a randomized controlled trial. Trials. 2021;22, 398. https://doi.org/10.1186/s13063-021-05350-1

Segmental dysfunction

Hypomobility

This variation on segmental motion is regarded as a hypomobile subluxation and is a restriction in segmental motion but not a fixation. This limited range of motion also needs to be restored to a physiological range of motion. The limited range may also be observed affecting spinal regional range or general stiffness. (Saunders, 1979; Vanderby et al, 1986; Sachse 1998; Gold, 2003; Richardson et al, 2004; Gatterman, 2005(c); Bakkum et al, 2007; Wong & Kawchuk, 2017; Nim et al, 2020)

> *'It has long been thought that 'joint complex dysfunction' (JCD) such as those treated by osteopaths only had detrimental effects on local joints and surrounding soft tissue due to the focus on the kinesiological component of JCD. More recent theories emphasise on the neurophysiological component involving afferent inputs to the spinal cords. By reviewing recent papers, it has been shown that hypomobility is associated altered reflex responses involving mechanoreceptive and nociceptive pathways … while improving mobility to restricted joints, it could have favourable influence on several neurological reflex responses by reducing abnormal inputs to the spinal cord, it could improve the body's ability to recover an optimal proprioceptive function.'* (Zegarra-Parodi, 2004)

Segmental and/or articular fixation

We would suggest that the articular fixation is one of the most common and significant forms of dysfunction to present in a manual therapist's clinic. Treatment for this element of a subluxation complex is directed at releasing the fixation, which is within its normal range of motion. As such, notions that such a release takes the joint beyond its normal range of motion is false. Indeed, if it occurred, it would result in ligamentous damage and would be a contraindicated therapeutic intervention.

In order to clarify from a chiropractic perspective, this discussion centres on a functional fixation within one or both articular facets normal range of motion, essentially affecting a segment's motion as static or aberrant – and its relationship with adjacent segments.

Schmörl and Junghanns (1971, p. 221) refer to vertebral fixation as locked mobility in the motor segment (Vertebral Locking). This term relates to a functional fixation of facets not a surgical fixation, fusion or arthrodesis. The clinical finding of vertebral fixation was noted by Gillet in the 1960s.

The release of this form of vertebral dysfunction seems to provide noticeable relief to patients. (Gillet, 1963 [Gillet, 1960s, Faye, 1970s.]; Alley, 1983; Innes, 1995; Senzon, 2018; Faulkner, 2021; Schafer, undated)

A classic example of altered joint motion in paired joints such as vertebral facets is that exhibited radiologically in temporomandibular articulations (TMJ dysfunction) where it is

possible to compare the motion of each side. (Nagata et al, 2019) Fisher et al suggest there may be an association with suboccipital subluxations. (Fisher et al, 2013)

Ishii et al found meniscus-like synovial folds in the facets to which they attributed atlantoaxial fixation. While Webb et al suggested that such folds are probably associated with symptoms of headaches and neck pain that may be relieved using spinal manipulation. (Ishii et al, 2011; Webb et al, 2020) Cramer et al noted that in animal studies, degenerative changes with induced segmental fixation, the severity of changes increased over time. (Cramer et al, 2006)

The neurosurgeon Finneson (1980) cited Mennell, Lewit and the chiropractor Henri Gillet in discussing mobilisation of '*fixated*' or '*locked*' posterior facet joints. (p. 249). He then notes '*vertebral malposition*', '*abnormal vertebral motion*' (p. 252) and '*subluxation*'. (p .251)

A recent Radiopedia article by Agrawal and El Feky discussed an atlas-axis fixation. They stated '*Atlanto-axial subluxation is a disorder of C1-C2 causing impairment in rotation of the neck. The anterior facet of C1 is fixed on the facet of C2.*' (Agrawal & El-Feky, 2022).

Aberrant motion

Aberrant segmental motion may be detected on palpation and at times on functional MRI imaging or plain film series. It is also evident on global motion of the neck where postural aberrations are evident on whole body or regional body movement. The aim of manipulation is to restore an unrestricted range of segmental motion. (Ellingson et al, 2013; Gopinath, 2015; Wattananon et al, 2017; Breen et al, 2018; Breen & Breen, 2018; Gatterman p. 266-73)

End-feel - joint play

Joint play or end feel is a type of active motion palpation assessment of a joint when it reaches the end of its range of motion. It generally contributes more information when employed on extremity joints. There is a range of sensations used as a diagnostic aid. (Physiopedia, End-feel, undated; Hayes & Petersen, 2001; Cooperstein & Haneline, 2008)

Extended reference compilation

Functional Vertebral Fixation.

Agrawal, R., Tao, W. Atlanto-axial subluxation. Reference article, Radiopedia.org. (accessed on Oct 2 2022) https://doi.org/10.53347/rID-942

Alley JR. The clinical value of motion palpation as a diagnostic tool: a review. J Can Chiropr Assoc. 1983;27(3):97-100.

Bakkum BW, Henderson CN, Hong SP, Cramer GD. Preliminary morphological evidence that vertebral hypomobility induces synaptic plasticity in the spinal cord. J Manipulative Physiol Ther. 2007;30(5):336-42. DOI 10.1016/j.jmpt.2007.04.007.

Cramer G, Budgell B, Henderson C, et al. Basic science research related to chiropractic spinal adjusting: the state of the art and recommendations revisited. J Manipulative Physiol Ther. 2006;29(9):726-61. DOI 10.1016/j.jmpt.2006.09.003.

Faulkner TJ, Foley J, Hynes RJR. The origins of fixation theory in chiropractic: does credit go to Dr. Oakley Smith or Dr. Henri Gillet? Chiropr Hist. 2021-2022;41(2):39-44.

Fernández-de-Las-Peñas C. Interaction between Trigger Points and Joint Hypomobility: A Clinical Perspective. J Man Manip Ther. 2009;17(2):74-7. DOI 10.1179/106698109790824721.

Fidler MW, de Lange J. Atlanto axial rotatory fixation--a cause of torticollis. Clin Neurol Neurosurg. 1979;81(2):114-8.

Fielding JW, Hawkins RJ. Atlanto-axial rotatory fixation. (Fixed rotatory subluxation of the atlanto-axial joint). J Bone Joint Surg Am. 1977;59 (1): 37-44.

Gillet H. The anatomy and physiology of spinal fixation. J Nat Chirop Assoc. 1963. (Cited by Vernon H. Historical overview and update on subluxation theories. 2010;17(1):21-32.

Gillet H., Liekens M. A further study of joint fixations. Ann Swiss Chirop Assoc. 1969;4:41–46.

Vernon H. Historical overview and update on subluxation theories. 2010;17(1):21-32

Gold GE. Dynamic and functional imaging of the musculoskeletal system. Semin Musculoskelet Radiol. 2003 Dec;7(4):245-8. DOI 10.1055/s-2004-815674. PMID: 14735424.

Gongal'skiĭ VV, Moroz NF. Meniskoidy sustavov pozvonochnika v norme i pri funktsional'nom blokirovanii pozvonochnogo segmenta [Vertebral joint meniscoids in the norm and in functional blocking of the vertebral segment]. Lik Sprava. 2002;(2):96-9. Russian. PMID: 12073274.

Henderson CN, Cramer GD, Zhang Q, et al. Introducing the external link model for studying spine fixation and misalignment: part 1--need, rationale, and applications. J Manipulative Physiol Ther. 2007 Mar-Apr;30(3):239-45. DOI 10.1016/j.jmpt.2007.01.006.

Henderson CN, Cramer GD, Zhang Q, et al. Introducing the external link model for studying spine fixation and misalignment: part 2, Biomechanical features. J Manipulative Physiol Ther. 2007 May;30(4):279-94.

Henderson CN, Cramer GD, Zhang Q, et al. Introducing the external link model for studying spine fixation and misalignment: current procedures, costs, and failure rates. J Manipulative Physiol Ther. 2009 May;32(4):294-302. DOI 10.1016/j.jmpt.2009.03.005.. https://chiro.org/Subluxation/The_Basis_for_Spinal_Manipulation.shtml

Hill CS, Borg A, Tahir MZ, Thompson DNP. Atlantoaxial rotatory fixation in childhood: a staged management strategy incorporating manipulation under anaesthesia. Childs Nerv Syst. 2021 Jan;37(1):167-175. DOI 10.1007/s00381-020-04727-y.

Innes K, How does the diagnostic aspect of motion palpation fit into your world of chiropractic adjustive procedures, or does it? Dynamic Chiropr. 1995;13(1): https://www.dynamicchiropractic.com/mpacms/dc/article.php?id=40017.

Ishii K, Matsumoto M, Momoshima S, et al. Remodelling of C2 facet deformity prevents recurrent subluxation in patients with chronic atlantoaxial rotatory fixation: a novel strategy for treatment of chronic atlantoaxial rotatory fixation. Spine. 2011;36(4):E256-62.

Kawabe N, Hirotani H, Tanaka O. Pathomechanism of atlanto-axial rotary fixation in children. J Pediatr Orthop. 1989;9:569–74.

Lantz CA. Immobilisation degeneration and fixation hypothesis of chiropractic subluxation. Chiropr Research J. 1988;1(1):21-46.

Lelic D, Niazi IK, Holt K, et al. Manipulation of dysfunctional spinal joints affects sensorimotor. Neural Plast. 2016;2016:3704964. DOI 10.1155/2016/3704964. Epub 2016 Mar 7. PMID: 27047694; PMCID: PMC4800094.

Reed, W.R.; Pickar, J.G. Paraspinal muscle spindle response to intervertebral fixation and segmental thrust level during spinal manipulation in an animal model. Spine 2015, 40, E752–E759.

Richardson CA, Hides JA, Wilson S, et al. Lumbo-pelvic joint protection against antigravity forces: motor control and segmental stiffness assessed with magnetic resonance imaging. J Gravit Physiol. 2004 Jul;11(2):P119-22.

Roche CJ, O'Malley M, Dorgan JC, et al. A pictorial review of atlanto-axial rotatory fixation: key points for the radiologist. Clin Radiol. 2001;56(12):947-58,

Rome P. Waterhouse JD. The fixation element of the articular subluxation: More than a vertebral dysfunction. Part 1 of a series. Asia-Pacific Chiropr J. 2021;1.3. URL www.apcj.net/rome-and-waterhouse.

Saunders HD. Classification of musculoskeletal spinal conditions. J Orthop Sports Ther.1979;1(1):3-15

Schafer RC. Ed. Neck and cervical spine injuries. In: Chiropractic management of sports and recreational injuries. 2e. Williams and Wilkins. www.chiro.org/ACAPress/Neck_and_Cervical_Spine_Injuries.html.

Schmörl G, Junghanns H. The human spine in health and disease. New York. Grune & Stratton. 2USe. 1971.

Vanderby R Jr, Daniele M, Patwardhan A, et al. A method for the identification of in-vivo segmental stiffness properties of the spine. J Biomech Eng. 1986 Nov;108(4):312-6. DOI 10.1115/1.3138620. PMID: 3795875.

Webb AL, Collins P, Rassoulian H, et al. Synovial folds - a pain in the neck? Man Ther. 2011 Apr;16(2):118-24. DOI 10.1016/j.math.2010.11.004.

Wong AYL, Kawchuk GN. The Clinical Value of Assessing Lumbar Posteroanterior Segmental Stiffness: A Narrative Review of Manual and Instrumented Methods. PM R. 2017 Aug;9(8):816-830. DOI 10.1016/j.pmrj.2016.12.001. Epub 2016 Dec 16.

Zegarra-Parodi R. Could joint hypomobility alter optimal proprioceptive information? AAOJ. 2004;Dec:24

Combined displacement and dysfunction

Cyriax recognised the fixation element of a subluxation and mobilising this irregular segment, yet dismissed the idea of a subluxation itself. (p. 53) He then discussed reducing the *'intra-articular displacement'* in the cervical spine. (p. 104) (Cyriax, 1965)

The physical medicine specialist Cailliet (1967), discussed a cervical VSC as a degree of luxation or subluxation in using a joint sprain as an analogy together with dysfunction. In the

lumbar spine he employs terms like facet impingement and mechanical irritation, impacted facets, unilateral impairment of joint motion and facet freezing, facet irritation. (Cailliet, 1966; 1967)

Schmörl (pathologist) and Junghanns (surgeon), recognised both a functional and incarceration (transposition) of vertebral segments, they incorporated and discussed a number of terms directly related to this biomechanical disturbance of vertebral articulations. These include:- (Schmörl &Junghanns, 1971)

- Articular locking (p. 376)
- Changes in spinal mobility (p. 394-7)
- Displacement (p. 250-1)
- Displacement of loosened motor segment (p. 214)
- Excessive mobility (p. 222)
- Fixed articular block (p 376)
- Functional disturbances, (p. 250-1)
- Fusion and immobility of the motor segment (p. 220-221
- Immobilisation of the motor segment (p. 213)
- Immobility (p. 223)
- Improper mobility (p. 223)
- Incarceration (p. 249,376) (synonym for *dislodgement*, *translation*, *transposition*)
- Incarceration and locking of the '*skull articulations*'. (p. 223)
- Inefficient motor segment (p. 213)
- Intervertebral instability (p. 222, 227)
- Intervertebral insufficiency (p. 213 - 229)
- Limitation of motion (p. 250 - 1),
- Locked mobility, vertebral locking (p. 200, 206, 221 - 3)
- Locked segment (p. 221)
- Locking of vertebrae (p. 213)
- *Loss of* 'functional equilibrium' (p. 223)
- Mobility block (usually temporary) (p. 213)
- Repositions (p. 376)
- Return to complete performance efficiency (p. 223)
- Rigidity of the motor segment (p. 213)
- Slight subluxations (p. 250 - 1)
- Spondylogenic disturbances (p. 227)
- Stiffening of the involved segment (p. 223, 250 - 1)
- Subluxation – spinal (p .222, 249 - 250)
- Subluxation defined (p. 376)
- Subluxation of motor segment (p. 249 - 50)
- Traumatic functional disturbances (p. 251)
- Vertebral instability (p. 215)

- Vertebral locking (p. 200, 222)
- Vertebral slipping and displacement (p. 375 - 94)
- Loosening of the motor segment, improper increased motility of the motor segment. (p. 213)

In further recognition of displacement and dysfunction, the radiologist Epstein (1976, Fig 15, p. 24) portrayed the finding of an atlantoaxial subluxation with asymmetry of the spacing of the lateral masses of atlas in relation to the odontoid, and differentiated it from a dislocation. (p. 24, 558), He also advocated a role for cineroentgenography (p. 113, 557) in demonstrating abnormal mobility (dysfunction).

In relation to asymmetry of joint spaces, he described the lesion '*When the articular facets are displaced but not over-ridden…the condition is known as "subluxation" … The term has wide acceptance, but partial dislocation appears to better describe the condition*.' (Epstein , 1976 p. 549)

References

Cailliet R. Low back pain syndrome. Philadelphia: FA Davis Co. 1966:39,44,60-85,88.

Cailliet R. Subluxations of the cervical spine including the 'whiplash' syndrome. In: Neck and arm pain. Philadelphia: FA Davis Co. 1967:60-85.

Cyriax J. Orthopaedic medicine: Treatment by manipulation and massage. Vol 2. 7e. London: Cassell. 1965;53,104.

Epstein BS. The spine: A radiological text and atlas. 4e. Philadelphia: Lea & Febiger. 1976;24,30,549,557-9.

Schmörl G, Junghänns H. The human spine in health and disease. New York. Grune & Stratton. 2US. 1971.

To be continued

This series will continue as Part 3 by reporting evidence of a somatic vertebrogenic element which may be associated with disturbances of biomechanical neurophysiological and other connective tissue structures associated with the *Vertebral Subluxation Complex*.

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See also

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