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CLINICAL

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

Part 10 Vertebral adjustment of the vertebral subluxation - more than manipulation

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Abstract: The emergence of a profession as a distinctly separate model model in health care is identified by its unique title. Similarly, its uniqueness may also be identified by its distinct use of particular terminology, otherwise it would be difficult to differentiate from any other profession. Consequently, chiropractic has developed two particularly distinctive terms, the vertebral *adjustment* and the vertebral *subluxation.* Due to being multifaceted, this latter term is becoming supplanted by the more descriptive term *vertebral subluxation complex* (VSC). Subluxation of peripheral joints may also be adjusted when indicated. Adjustments are an advanced, specific and finely tuned form of the generic term manipulation.

Indexing terms: Vertebral subluxation; Vertebral adjustment; chiropractic.

'Studies detailing the neurophysiological effects of spinal manual therapy have fuelled a paradigm shift away from a strict biomechanical model.' (1)

> *... The generic term manipulation represents a more general, non-specific attempt to broadly mobilise a number of joints at the same time. As an analogy, one does not manipulate a radio dial, vehicle brakes, one's glasses, or binoculars. These should be carefully adjusted with considered, controlled, and precise actions.'*

Introduction

From a somatosensory viewpoint, the terms *vertebral subluxation* and *vertebral adjustment* may identify both the rationale for the clinical presentation, and the process for remediation of associated signs and symptoms. Under this VSC model, consideration is focused on the somatosensory origin impacting on neurophysiological reflexes of the autonomic nervous system (ANS). The literature and clinical reports indicate that addressing and correcting the specific VSCs contribute towards a significant and authentic contribution to a patient's comfort and well-being in assisting recovery from a range of subluxation-related conditions. (2, 3, 4, 5, 6)

In this review, the following definitions are offered:

- A subluxation is an articular dysfunction, typically but not limited to the spine and pelvis, characterised by anatomical and neurophysiological signs and symptoms.

- In consideration of this definition, the correction of a subluxation is called an adjustment. It may be defined as

> The physical application of a highly developed form of manual or instrument intervention directed to restore joint and neural physiology in order to ameliorate associated signs and symptoms.

The chiropractic interaction

Prior to accepting a patient for chiropractic care, a patient's past health history, current symptoms and examination findings, are assessed, explained, and recommendations outlined. Based on certain signs and symptoms, a spinal examination may determine the presence of aberrant movement or positioning involving vertebrae.

It is then decided as to which management model, manipulative technique, or referral, is indicated. If VSCs are present, a vertebral adjustment corrective procedure or a manipulative mobilising intervention may be conducted. This would be with the intention to re-establish the normal joint physiology (i.e. mobility and position) of an aberrant osseous segment or segments in order to normalise somatosensory input.

It would usually be conducted on a particular spinal segment(s) in a specific corrective direction, and to a specific degree. Frequency of care would depend on severity and duration of lesion, age, lifestyle, diet, work habits, residual posture, previous traumas, hobbies and sports played. It would take into account consideration of the orientation or plane of the articulations involved, as well as patient safety comfort and preferences, and the practitioners preferred technique for a particular finding. (7, 8, 9, 10, 11, 12, 13, 14)

Essential information to guide the chiropractic adjustment

This *chiropractic adjustment* is based on this pre-determined analysis, focused on an identified spinal biomechanical lesion. The *adjustment* is implemented as a refined form of the more generalised and non-specific manipulation. It may be considered at the highest order of psychomotor skills on the manipulation spectrum. (7) Vertebral subluxations (VSCs) involving spinal articulations are generally adjusted more frequently than peripheral joint subluxations in most chiropractic practices.

Optimal segmental mobility, positioning, intrinsic muscle tone, as well as localised tenderness are some of the clinical indications which may be identified with such a clinical finding. These correspond to a recognised degree of inter-examiner reliability in assessing an involved segment. (14, 15, 16, 17, 18, 19, 20) In determining the particular segment for attention, Triano and colleagues noted that '*In general, the stronger and more favourable evidence is for those procedures which take a direct measure of the presumptive site of care- methods involving pain provocation upon palpation or localized tissue examination*.' (21)

When a spinal lesion becomes a vertebral subluxation complex

The composite of factors comprising a *subluxation* identifies the lesion as a complex (VSC). Shaballot et al infer a somatovisceral association with the diagnostic value of segmental signs in relation to visceral disease. (22)

The localised nature of the *vertebral adjustment* is attributed to its focus on thrust, segment specificity, displacement, amplitude, duration, velocity and direction, with due consideration in its application to the afferent and efferent neurological signs and symptoms associated with that subluxation. (22)

One version of an *adjustment* is referred to as a *High Velocity Low Amplitude* (HVLA) thrust. When compared to mobilisation or general manipulation, HVLA is perceived as not only being more corporal, but having a more positive and effective influence in ameliorating the objective patho-neurophysiology and pathomechanical sites. However, the HVLA term is open to subjective interpretation and therefore somewhat meaningless unless qualified. (23)

Similarly misinterpreted is the notion that an adjustment takes segments beyond their normal range of motion. We, among others, have shown this to be a nonsense. (23, 24)

In recognising somato-sensory stimulation from a noxious mechanical segmental disturbance, Sato opined that due to neurological influence, there can be a '*decrease in blood pressure and renal activity during manipulation of the spine and that these are thought to be due to supraspinal reflexes*.' He confirmed that these findings could be associated with spinal joint afferents. Such somatovisceral reflexes would tend to clarify and substantiate the rationale for the manipulative management of conditions which may have the potential to affect aspects of the physiological function of internal organs. (25)

In 2012, Haavik and Murphy outlined the criteria justifying a role for chiropractic intervention involving somatosensory aberrations. This was preceded by their 2010 research which concluded that '*cervical spine manipulation may alter corticol integration of dual somatosensory input*' in the relief of pain. (26, 27)

Other independent recognition of the neural implications of manipulation has been acknowledged in a 2007 study by the physiotherapists Bialosky et al, at the *University of Florida*. They studied the effect and rationale of manual therapy on musculoskeletal pain. Their conclusion found physical intervention under '*... this model suggests that a mechanical force from MT (manipulative therapy) initiates a cascade of neurophysiological responses from the peripheral and central nervous system which are then responsible for the clinical outcomes ...*' (28)

It is therefore suggested that localised activated noxious articular somatosensory blitz is bound to also affect associated visceral tracts and not be confined to a somatic distribution. (29, 30)

After the adjustment

Following adjustment(s), spinal mobility exercises may then be implemented to complement maintenance of a released segment(s). Strengthening and stabilising core exercises may be advised under a management plan for hypermobile states to augment segmental stability. These are intended and facilitate a more natural vertebral articular physiology in maintaining spinal integrity. (31)

The vertebral adjustment takes into deliberation factors including identification, specificity, amplitude, direction, potency, segmental motion, and speed of thrust. The imprecise nature of general procedures differs markedly from a specific chiropractic adjustment with its nominated, localised objective, and neurological considerations.

By contrast, spinal manipulative therapy (SMT) and manual therapy are generic terms covering a variety of general manual manipulative procedures of joints and other structures. (32-35) Wikipedia (36) lists 55 subcategories of manual therapy. Examples of the broad gamut of non-specific manual therapy techniques include the following:

- Acupressure
- Articulatory technique
- Balanced ligamentous technique (BLT)
- Counterstrain technique

- Facilitated positional release
- Joint manipulation
- Lymphatic technique
- Massage
- Medical acupuncture
- Muscle energy technique
- Myofascial release
- Osteopathy in the cranial field/Balanced membranous technique
- Peripheral joint manipulation
- Peripheral joint mobilisation
- Soft tissue technique
- Structural integration
- Thrust technique
- Visceral manipulation

Adjustment delivery

The vertebral adjustment may also be delivered manually or by a technically sophisticated, precise, controlled, mechanical impulse instrument. The application of this impulse can be precisely modified depending on the considered analysis of factors in the presenting case. (37, 38, 39, 40, 41, 42, 43, 44, 45)

In essence, the variety of manual techniques becomes somewhat ambiguous when it includes such a wide range of procedures. There is a need to clarify the fact that chiropractic, osteopathy, and physiotherapy are not manual techniques, but are distinct professions and health service providers in their own right. It is therefore necessary to differentiate the chiropractic spinal adjustment as to diagnosis, specificity, purpose, efficacy and scientific rationale as distinct from other forms of manual intervention. (46, 47) It is important to specify the technique used in any manual manipulative procedure otherwise comparisons of efficacy would not be available.

Manipulation is a low-order manual skill

The generic term manipulation represents a more general, non-specific attempt to broadly mobilise a number of joints at the same time. As an analogy, one does not manipulate a radio dial, vehicle brakes, one's glasses, or binoculars. These are carefully adjusted with considered, controlled, and precise actions. (48)

Evidence suggests that manipulation without cavitation has notably less physiological, neurological, and joint mobilising influence. Findings indicate that a single spinal manipulation treatment does not necessarily alter the corticospinal or stretch reflex excitability of the *erector spinae* muscles, when assessed approximately 10-minutes following spinal manipulation (SM). However, they do indicate that the stretch reflex is attenuated when SM causes an audible articular response. The neural effect associated with this cavitation also provides insight into muscular mechanisms of manipulative procedures by monitoring the H-reflex. Cavitation suggests that so-called HVLA adjustments which produce this audible response/release may mechanistically act to more effectively decrease the sensitivity of the muscle spindles and/or the segmental sites of the 1a neural reflex pathway. This assists in the relaxation of muscle hypertonicity and muscle splinting. (49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61)

Mobilisation is a notably milder form of general, non-specific manipulation. Research suggests that it has a more limited positive influence on the neural elements. (62, 63, 64, 65)

However, a 2008 study by Schmid et al, found that apart from an hypoalgesic effect, manual influence (segmental neurological modulation) upon neurophysiology is even noted when '*passive joint mobilisation stimulated areas within the central nervous system*' through descending spinal cord pathways. As such, one would expect HVLA technique to impart an even greater neuromodulatory influence and efficacy due to the effect on a greater number of receptors. (66)

A chiropractor generally specialises in a specific adjustment, but in addition may incorporate any one, or a combination of manual or instrument interventions depending on palpatory findings and other clinical indicators. The technique would be selected to synchronise with the particular patient at the time.

Chiropractic practice is not limited to manual procedures, but patient management may incorporate such regimens as exercise, muscle energy procedures, dietary considerations, lifestyle advice, sport participation, hobbies, stress management, and occupational considerations among others. (67, 68, 69, 70, 71, 72)

Adjustments of vertebral subluxations and their neural impact

Herzog and colleagues (73) have demonstrated that a somatic neurological reflex response was associated with spinal adjustments. The response indicates activation of central neural reflex pathways. Colloca and Keller noted similar responses. (74)

In a medical paper, Vaňásková and colleague further acknowledge the vertebrogenic phenomenon when they state that '*A motion segment dysfunction may activate latent disease in an internal organ*.' (75)

Traditional resistance to concepts regarding the neurological implications of chiropractic principles appears to be dissipating. In 2008, Schmid et al stated that '*Segmental neurological modulation, neural hysteresis and biomechanical effects have been proposed as mechanisms underpinning the effects of manual therapy*.' Their conclusion further supported the concepts when they stated '*Our review supports the existence of an alternative neurophysiological model, in which passive joint mobilisation stimulates areas within the central nervous system*.' Although just mobilisation, further recognition followed three years later when Hegedus and colleagues stated '*Recently, a paradigm shift has taken place in manual therapy as an increasing number of studies support a predominantly neurophysiological mechanism of benefit with joint mobilisation.*' (1, 66)

Limited recognition of the medical interest and potential of spinal manipulation was noted in the *New York Medical Journal* over a century ago in 1913. The medical doctor R Kendrick Smith used the term '*mechanical physician'* in respect to '*the efficacy of mechanical treatment for remote, obscure, systemic or organic diseases*.' (76)

Dishman described the intervertebral biomechanical element of a vertebral subluxation as '*... a biomechanical fault which is abnormal in both its dynamic and static components. A subluxation may be considered as being fixated and also slightly malpositioned in one or more axes of rotation. Subluxation may be considered as one component of a complex or syndrome of intervertebral dyskinesia, dysarthrosis or dysfunction*.' Other essential considerations relate to the neural ramifications sufficient to initiate physiological changes of target organ or structure's function. (77)

In addition to a range of musculoskeletal conditions, chiropractic researchers and others have explored, noted, and employed the integration of the autonomic nervous system. They have been able to demonstrate a manipulative effect upon this governing neural network. Colloca et al monitored mixed nerve root action potentials on exposed nerves during a human surgical procedure. Haavik and colleagues have conducted extensive research fundamental to the

chiropractic model. Further examples of chiropractic neurophysiological research over some decades include studies by Budgell, Bolton, Colloca, Cramer, Henderson, and Pickar, amongst many others. (20, 39, 77, 78, 79, 80, 81, 82, 83, 84, 85)

The influence of pain through the ANS occurs with the convergence of spinal and visceral afferents forming the spinothalamic tract in the dorsal horn. This then flows to the *tractus solitarius* and *parabrachial* nuclei. This central integration of noxious somatosensory sensitisation may play a role in the hypoanalgesic effects of vertebral adjustments. These are thought to be established as homeostatic reflexes with central sensitisation, with segmental lateralisation being a diagnostic factor at times. (22, 66, 86, 87, 88, 89, 90, 91)

This mechanism is a somewhat similar pathway to that of autonomic interactions of some forms of primary headaches which are regarded as a visceral pain. (92, 93, 94, 95, 96,) Benarroch notes further the interactions of pain with the autonomic nervous system, as well as an association with endocrine function and specific CNS structures by stating '*There are extensive interactions between the neural structures involved in pain sensation and autonomic control. The insular and anterior cingulate cortices, amygdala, hypothalamus, periaqueductal grey, parabrachial nucleus, nucleus of the solitary tract, ventrolateral medulla and raphe nuclei receive converging nociceptive and visceral inputs from the spinal and trigeminal dorsal horns and initiate arousal, affective, autonomic, motor and pain modulatory responses to painful stimuli*'. (88)

Given the recognised association of the cervical spine in various forms of headaches, segmental adjustments of this region has been recognised as a circuit breaker to diminish or resolve symptoms of cervicogenic headache. (88)

Where noxious spinal neural activation occurs, Carrick suggests that the vertebral adjustment is a particularly influential source of a controlled, neurological remedial stimulus impacting the nervous system. This would be achieved by a cavitation-type release accomplished with the firing of so many joint mechanoreceptors, especially those from vertebral articular facets. (14, 97, 98)

An integral factor in the vertebral subluxation complex is neural activation. As joint mechanoreceptors (JMR's) comprise both small diameter afferents (SDA) and large diameter afferents (LDA), the neural input is greater than for SDAs alone. In nerve conduction velocity, the largest myelinated fibres are faster, and therefore have a greater chance of summation. In regards to the velocity, the 1a afferents (LDA's) are fastest in sensory nerve speed, with an impulse velocity of up to 120m/sec. This compares to Group III and the unmyelinated Group IV afferents (SDA's) ranging from 30 m/sec down to 0.5 m/sec respectively. (99) Under inflamed conditions, the volume of afferent discharges can increase more than 100-fold. (25 p54) Vertebral adjustment would seek to normalise this heightened noxious neural input.

Budgell and Sato noted that '*The most consistent and potent reflexes are induced by noxious stimulation or the activation of unmyelinated afferent fibers. Somato-autonomic reflexes can be sub-divided into A- and C-reflexes, which are elicited by stimulation of myelinated (A) and unmyelinated (C) afferent fibers, respectively, in somatic nerves.*' (84) Thus corrective suppression of noxious sensory input would be indicated as in cases of irritated and inflamed and subluxated vertebral facet(s), the removal of such a strong noxious insult could conservatively conducted through manually modifying the noxious input of the disturbed articulation. This is a routine procedure in chiropractic practice.

In relation to receptors, Cramer and Darby state that '*The classification of receptors by location overlaps with the classification by stimulus type, such that nociceptors can also be exteroceptors, and mechanoreceptors can also be proprioceptors.*' These properties would exacerbate the sensory feedback. This may also emphasise the significance in highly activated noxious input in stimulating the autonomic reflex arcs, and constitute a vehicle to positively influence the ANS when assessed for vertebral adjustments to remove that input. (100)

Chronic subliminal/subclinical somatosensory activation

Apart from aberrant proprioceptive and other mechanoreceptor input, degrees of pain are a most common noxious activator of somatosensory reflexes. It may present in various forms, such as acute, chronic, subclinical, or subliminal. There is also a range of classifications for pain in the literature. (50, 101, 102, 13, 104, 105, 106, 107, 108, 09, 110, 111, 112)

Touj and colleagues' statement that '*Chronic pain is associated with autonomic disturbance*' would indicate that the severity and chronicity of the pain may also impact somatovisceral reflexes. The varying degrees of pain or tenderness such as nociceptive, neuropathic or inflammatory noxious activation can be convenient signs or symptoms to be clinically interpreted. (113)

Regardless of controversies about chiropractic subluxations or manipulation, patients are aware when their levels of pain decrease or are eliminated. That relief potentially has a wider benefit than just the respite from localised segmental pain. Using functional magnetic resonance imaging (fMRI), Baliki and colleagues found that their findings on chronic lower back pain patients 'demonstrated that chronic pain has a widespread impact on overall brain function.' Furthermore, Apkarian et al found that chronic pain is estimated to reduce cortical gray matter by up to 11%. (114, 115, 116)

In a further indication of the wider ramifications of pain, May and others also opined that the structure of the gray matter in the brain changes with chronic pain patients. They stated further that the changes can be reversible when the pain is alleviated. As spinal pain is a common condition addressed through vertebral adjustments, the procedure may be shown to positively reconstitute the affected region of the brain. (117, 118, 119)

Burton and colleagues noted that '*... incapacitating effects of long-lasting pain are not just psychological – reflexes driven by nociceptors during the establishment of chronic pain may cause serious physiological consequences on regulation of other body systems.*' (120)

Constant firing as a chronic bombardment of subliminal noxious insult may be seen as a predisposing factor for subsequent more prominent symptoms, or syndromes. Schmorl and Junghanns refer to this neural activation as '*subthreshold autonomic nerve irritation*'. (101, 121, 122)

In 1990, van Buskirk suggests that sustained sympatheticotonia associated with chronic segmental facilitation, is a response to nociceptive input to the reflex arc. In essence this exemplifies a neural irritation component of mechanoreceptors within a vertebral subluxation. (123)

A number of studies explore the neural insults from noxious somatic firing due to acupuncture needling, external mechanical insult, and joint injections of capsaicin or saline. (70, 122) However, there appears to be a limited number of studies examining these effects on visceral function from these chronic, lower threshold somatic neural stimuli. A further version may be the subtle, subliminal noxious input from occult somatosensory input over extended periods of time.

In 1976, Hadley also noted neural disturbance elsewhere when he alluded to '*chronic cervical syndrome*'. He identified associated somato-autonomic factors with symptoms such as; 'paroxysmal deep or superficial pain in various parts of the head, face, ear, throat, or sinuses' as well as '*sensory disturbances in the pharynx, vertigo and tinnitus, with diminished hearing,' and such vasomotor disturbances as 'sweating, flushing, lacrimal salivation*'. (124)

In 1984, Camilleri and colleagues studied sustained somatic stimulation of the abdominal skin surface. Using a TENS unit, they stimulated abdominal (T5-T10) and hand (C8-T1) dermatomes which induced a somatovisceral response in the form of a slower gastric motility. They reported that '*sustained somatic stimuli resulted in reduced postprandial antral phasic pressure activity (and*

that) induced somatovisceral responses relay predominantly at the cerebral level.' This sustained input may be compared to the chronic neural input from milder nociceptive biomechanical somatosensory disturbance, such as a limited vertebral subluxation with potentially similar visceral affects. (125)

Burton and colleagues noted that long-lasting pain can have psychological as well as physiological effects. The latter being an impact on regulation of other body systems including the cardiovascular system. This could suggest that the removal of spinal pain by vertebral adjustment may tend to assist in the alleviation of psychological factors in some patients. (120, 126, 127)

Budgell and Sato noted the duration factor in 1996 when they stated '*it is apparent that somatic stimulation is capable of causing widespread and, at times, profound visceral responses, both in the short and long term.*' (84)

Somatosensory proliferation or bombardment should be worthy of further analysis as to its impact with noxious somato-autonomic, and somatovisceral reflex activation. Clinical evidence as to the role of particularly noxious nociceptive and mechanoreceptor impact upon the parasympathetic and sympathetic nervous systems was highlighted by Sato and other researchers, but clinically seems to have received relatively little attention except by chiropractors and osteopaths.

The 'sleeping' or silent subluxation

The concept of dormant or silent nociceptors may explain sudden, spontaneous activation of symptoms in response to noxious and even innocuous stimulus intensities. (121 p 227; 128, 129) Jessell and colleagues stated that '*Although each nociceptor can have a variety of possible threshold levels, some do not respond at all to chemical, thermal or mechanical stimuli unless injury has actually occurred. These can be typically referred to as silent or sleeping nociceptors since their response comes only on the onset of inflammation to the surrounding tissue.*' (130)

It has been noted that a more subtle form of noxious insult may result from a mildly disturbed vertebra, possibly a limited or partial (restrictive) fixation form of subluxation. This may result in low level sensory simmering for a period of time, perhaps only to be aggravated or re-activated later by a further relatively mild trauma, one not considered severe. It may also resolve spontaneously depending on the severity of the etiology, or it may resume quiescence. Either way, it is suggested that it would invite segmental adjustment(s). Budgell states that '*It is possible that such non-pathological pain can still produce clinically significant changes in visceral function.*' (131)

The term asymptomatic subluxation, the *silent subluxation*, appears somewhat akin to silent migraine, acephalgic migraine, or migraine equivalents. Silent subluxations may provide further rationale for maintenance and preventative care in chronic recurring mechanical spinal pain. (132)

Further research may differentiate the pathophysiological differences between a VSC which, when identified, appears to be purely dysfunctional, and diagnostic signs but without symptoms. That is, one with objectively determined localised tenderness or pain, and one which produces more complex symptoms such as sciatica, dyspepsia, a muscle weakness, or altered HRV. (140)

Cavanaugh and colleagues noted that the stretching of a facet capsule can lead to prolonged neural after discharges in muscles (myotonia) as may happen in whiplash. They suggest further that this can affect neural axons in the capsule and result in firing silent nociceptors. They also suggest that this may be a factor in chronic neck pain following injury. It may also explain chronicity of some injuries and the difficulty in demonstrating the cause of such symptoms in whiplash litigation. In addition they note that '*facet-joint capsules contain low-threshold*

mechanoreceptors, mechanically sensitive nociceptors, and silent nociceptors' thus making vertebral articulations a recognised site for symptoms and manual attention. (141)

A further consideration may depend on which particular nociceptors are activated. For instance, capsular receptors may react differently and produce different signs and symptoms compared to say, articular cartilage, ligamentous, or tendinous firing of nociception. This differentiation has yet to be identified. (142)

Conclusion

The subtleties of the pathophysiology of a vertebral subluxation and the specific adjustment encompass a range the physiological effects at each segmental level. The adjustment also differs from a general manipulative manoeuvre. Further research could be expected to reveal the extent and precise neural mechanisms to which subluxated vertebrae may impact. In particular the level of intensity and duration which may influence ANS physiology.

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