1. The problem with subluxation

> 'The history of the profession is riddled with failed attempts to bring unity to Chiropractic by defining, redefining, updating or developing "new" meanings for the word subluxation'.
>
> FVSR White Paper, 2025, p. 1 (48)

The problem with subluxation is political, not scientific nor philosophical. Subluxation has strong clinical relevance within the practice of Chiropractic, being integral to some 80% of the profession globally (1) and is overt in more than 1,600 peer-reviewed, indexed Case Reports [Terms: 'subluxation' AND 'case report' OR 'case study' OR 'case series'; AND 'peer reviewed'] as of May 2025. (2) While frequently reporting surrogate indicators (3) of subluxation, not one of these reports gives material evidence of the nature sought by those working within the confines of fundamental physical ontology; to do so requires space-time structures which have definite locations, I call these a '*local beable*' after Tim Maudlin. (4)

The literature fails to report any such '*local beable*' which could reasonably be shown to be a vertebral subluxation (5)

yet it is a mistake to think this implies a non-scientific or non evidence-based existence. While we cannot consistently describe what this '*local beable*' could be, or as some would like to think, *should* be, we can reasonably call it a subluxation based on the constellation of clinical evidence gathered to validate the Chiropractor's clinical therapeutic intervention, the adjustment. This becomes their perspective-dependent knowledge claim which I have previously reported. (5)

Some theories of subluxation have been gathered (6) and expounded (7) yet there are no hypotheses educed from these nor any proposal to test them. We have no option but to classify what Vernon (8) terms the '*archetypal elements of Palmer's theory*' as unproven hunches. Vernon gives these as:

1. Subluxation, which is a misalignment of one of the vertebrae, causes
2. Pressure on nerves exiting around the vertebrae, causing
3. Disease (I will ignore the semantics of 'disease' vs 'dis-ease')

Therefore,

4. Removal of subluxation (by manually adjusting it to its correct position) causes
5. Release of nerve pressure, causing
6. The restoration of health. (8)

I have given the origin and evolution of Vernon's 6-step Palmerian Theory as Chiropractic Principles in detail in Chapter 2 (pp. 28-59) of my companion volume. (9) Critics have referred to these as '*potentially testable, theoretical*

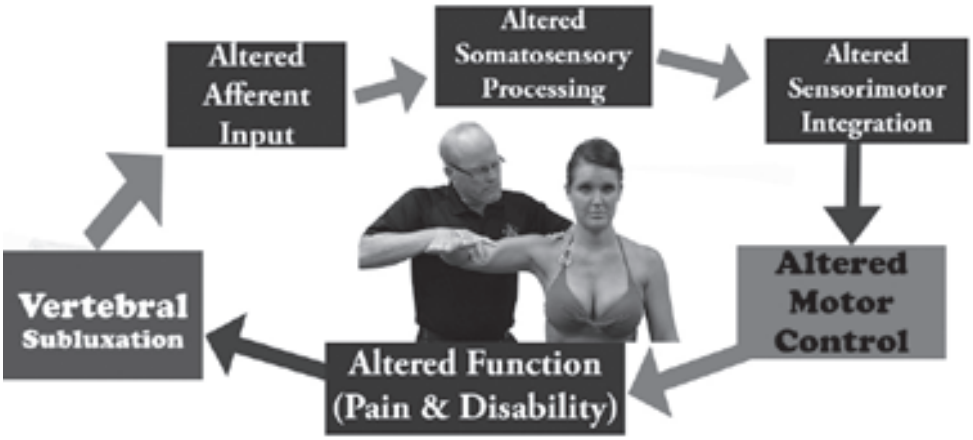
construct[s] for which there is little experimental evidence'. (10) The trouble is, nobody has advanced beyond the 'construct' stage to generate a falsifiable theory.

As logical as Vernon's summation seems to be, I can't accept it as representative of any 'theory of subluxation' which means we need to go back to square one. I am also concerned by Vernon's reliance on causation in his inductive reasoning from one observed event to the next, notwithstanding this being the right approach to developing a theory. This point has value in separating logical thinking from wishful thinking or deductive reasoning. It is also here that the 'scientific divide' occurs with subluxation where we find some academics (11) saying there is no evidence for it and worse, that it can not be taught. It may simply be that these folk fail to understand how science 'works' and are looking for things which not only do not exist, but cannot exist.

In this same vein I contend that physical quantitive dimensions of subluxation do not and can not be shown to exist, if only for the simple reason there are far too many moving parts within these clinical indicators or, as Rosner (58) calls them, '*surrogates*', for our minds to be able to manage. There is also the complication that the dimensions associated with purported movement change are very small, about 1°.

Clinical surrogates are highly relevant to those Chiropractors practicing within the paradigm of Applied Kinesiology as I show in Figure 1.1. They suggest five categories of clinical findings which provide input data to the practitioner, and in other models of the Vertebral Subluxation Complex (VSC) you will see similar categories.

Figure 1.1: An AK view of the moving parts of vertebral subluxation. Courtesy of Dr Scott Cuthbert.



In the most broad terms these categories include:

- a belief that the vertebra exhibits a different movement pattern to its contiguous fellows. This started with the belief of Palmer that the spinous process was an indicator (12 p. 37) '*to locate the displacement and the affected nerve by the contour of the spinous processes*' which became a fixation concept with Sandoz (13) and an altered motion concept with Faye. (14) This is given as 'Altered Function' and is often accompanied by pain and tenderness about the specific segment/s which may be sufficient to be considered a disability;
- a belief that the connective tissue supportive of spinal mobility units may be compromised by being either too lax (hypermobility, a concern within the SOT paradigm) or too contracted (hypomobility) observed as altered and unequal movements where equal movements are expected. There is also traumatic, congenital, and biochemical damage, notably with the

transverse ligament of C1. This could also be classified mechanically as 'Altered Function';

- a belief that there is muscle involvement in some way or another. It is here that the categories move from mechanical to become functional, as local muscle may be over-facilitated and contract to mechanically restrict vertebral movement, or both local and distal muscles may become altered in their function secondary to a compromised nerve supply. This broad category subsumes the three upper categories of 'Altered Afferent Input', 'Altered Somatosensory Processing', and 'Altered Sensorimotor Integration'. Each of these categories represents a fine level of dysfunction within the VSC and those calling for Newtonian 'evidence' of subluxation must devise clinically effective methods to document each. Without this, they will never find the evidence they naively demand;
- integral to all categories is the belief of altered neural function in some form. This can be afferent or efferent, local or distal, segmental or whole body, expressed as pain or dysfunction and important, including cognitive and affective changes. The simplistic explanation is a narrative about occlusion at the Intervertebral Foramen, perpetuated by authors such as Boone and Dobson (15) but argued both for and against by Palmer the Founder. (12 eg pp. 37, 38, 64; 16 eg pp. 69, 91). Palmer did not favour 'occlusion' as he held that neural flow could be either too much, which could not occur with an occlusion of the nerve, or too little, which could. I am painfully aware that my overview here of

the neurological dimensions of the VSC is crude and basic. The neurological dimension is actually evident in all categories of any model.

- the 5th accepted category is vascular and again this is multidimensional, ranging from oedema to constriction of cardiac arteries producing a pain that mimics angina, a somatovisceral effect. Often overlooked in clinical assessment is impaired lymphatic drainage. There may be vascular-induced pains in cervicogenic headaches and other vascular effects we are yet to identify.

My point here is that diagrammatic representations of the approach of any paradigm of care within Chiropractic widely exist and the AK paradigm shown in Figure 1.1 is just one such paradigm. As Dave Russell concluded '*The assessment and correction of vertebral subluxation is a core clinical objective in the practice of chiropractic. Chiropractors in clinical practice, chiropractic educators, and chiropractic researchers are encouraged to address the identified gap in the evidence by documenting the common used direct indicators of vertebral subluxation used both in the initiation of care or a clinical trial and at each progress evaluation or post the completion of clinical trial outcome measurements*'. (17)

There is no appeasement of 'evidence-absolutists'

Whilst acknowledging that any combination of the above may represent an ontological statement about subluxation, what exactly do

> the evidence-absolutists mean when they hold that there is 'no evidence'?

This is the political question which can never be answered by the smug rejection of any and all evidence. It is the classic, political Catch-22; the evidence abounds but is deemed unacceptable by eminence, effectively locking these evidence-absolutists in a 3-Dimensional Newtonian prison of their own making.

It may simply be that they are untrained in the science for examining a complex problem, which subluxation is. (5) I revisited my original writings on subluxation as a complex problem in the companion volume to this textbook (9 Chapter 7 Part 3 pp. 231-5) and on appreciating the complexity of attempting to examine the matter in the Newtonian paradigm proposed a more sophisticated paradigm built around philosophical understandings particularly those observed through the lens of Pragmatism.

The following is my attempt to bridge the elitist divide of insouciant superiority evident with the position of the GCC (11) and the evidence-free echo of a handful of colleges gathered as The International Chiropractic Education Collaboration (ICEC). (18) I note that the Canadian Memorial Chiropractic College (CMCC), one of the protagonists of this Collaboration is now obfuscating its antagonism to subluxation by claiming '*The term "subluxation" is often very confusing*' (19) and then offering some politically correct guff representing an each-way bet. It is positive to see that this institution recognises it may have gone too far in its antagonism, after all, it was a CMCC President who called the proponents of subluxation

the '*gangrenous arm of the profession*', (20) however there would be greater academic good to be gained should CMCC properly resource its academics to lead investigations into a better understanding of what it is that they consider '*confusing*' and attempting to resolve this.

This is unlikely to occur however as it seems the majority of CMCC's academics have drunk the Kool-Aid; an official statement from CMCC notes '*There was overwhelming support (98%) by the faculty of the content of the Position Statement*'. (19) Mind you, the vote was taken on a group of proposals, most of which were logical and attractive, speaking to 'quality' and other nebulous academic aspirations. The anti-subluxation statement was a buried bullet point and it is likely that many of those who voted for the position failed to actually read it in detail. A more convincing finding would flow from a poll on the anti-subluxation statement alone, however the institution is clear in stating that '*CMCC does not support the use of the term "subluxation" in its vitalistic context as promoted by BJ Palmer or Stephenson*'. (19 p. 2 dot point 4) I note this view is contrary to the literature on the topic, where Richards avers '*vitalism as a fundamental ontology existing in chiropractic*'. (21) In stark contrast to the GCC and the CMCC and those few colleges affiliated with it stands the Rubicon Group of colleges (22) with a philosophy rooted in neo-vitalism, the traditional principles of Chiropractic, and a neurologically-centred model of subluxation.

What follows now are basic Philosophical steps for gaining knowledge of our world as 'Scholarship 101' and which may contribute towards resolving the confusion afflicting CMCC, some other institutions, and the GCC.

The ontology of subluxation

It is reasonable to first identify an ontology of subluxation. I'd prefer one with which I am comfortable as long as it tells us what subluxation is or at least the nature of it as a perceived reality. The best I can do is to work with the idea of subluxation as it has always been across several thousand years of human medical writings, (23, 24) a discreet dysfunction within a vertebrate's spine or other joints reported as being associated with clinical findings. As we work our way through the many definitions we will see this most basic of ideas expressed in varying levels of detail or brevity.

In response to the research question '*what is the ontology of subluxation*'? I would respond with a statement that expresses what I believe I know to exist:

> 'The collective noun 'subluxation' is used within the discipline of Chiropractic by Chiropractors to predominately denote one or more clinical signs and symptoms evidenced on and by physical examination. Conceptualised as exhibiting elements of biomechanical dysfunction to variable degrees, subluxation may be identified in a specific joint complex of the spine, known as a 'spinal mobility unit', or other structures and is corrected manually using a hands-only controlled and rapid therapeutic thrust with intent. The thrust may be mechanically assisted. The outcome of such a correction is an adjustment of systemic neural tone which

> may be supported with lifestyle elements from nutrition to exercise.'

Elsewhere (25) I have described in detail the genesis of the above paragraph and note that it holds universal meaning, which means that it conveys the same idea in any one of about 17 languages. Acceptance of this universal meaning brings ontological commitment which can be summarised as being that acceptance of the meaning confers the status of a variable on the idea of subluxation. It is this which makes the understanding of subluxation in Chiropractic a complex problem, as there is also a second variable which is what is 'done' to or with the subluxation. Of course, these two variables occur within the greater variable of a patient with all their individual uniqueness. These three significant variables remove any chance of any two ideas of subluxation and its treatment being exactly the same.

Why I am talking about the 'idea' of subluxation?

- I do not yet see subluxation, as applicable within Chiropractic, as an absolute while appreciating many Chiropractors do. It is this disconnection which I am exploring in this textbook. To be an absolute there must be a description which is falsifiable, and such is yet to be published;
- the description of subluxed vertebrae as 'subluxation' emerged in the first decade of the discipline as founded by Palmer yet this does not mean the entity only appeared at that time. As Bovine and I have reported (23) the clinical findings now representative

of subluxation in Chiropractic have been known for thousands of years;

- it follows that the long-existing clinical findings may have been named something different or indeed may not have been named at all prior to Palmer's work. A name does not confer validity but rather acknowledges the 'idea' that the findings have some meaning, after all, the long-term documentation of what we call subluxation is actually talking about 'something' experienced as a clinical entity at the time;
- the fact, rooted in history, that DD Palmer formalised a long-standing and well-known, in the medical literature, clinical problem as subluxed vertebrae and devised a painless means of manual correction, is conflated as '*religious thinking*' by Young. (26) Using less than convincing arguments Young likens to a religious belief the pioneering approach by different paradigms of early Chiropractic for investigating X-rays as a diagnostic tool.

When subluxation is ridiculed or denied then those who do so are left with no way of explaining the patient's clinical picture. In Young's case the exclusion of X-rays from the process of patient assessment removes a critical diagnostic tool (27) and endangers patient safety. Worse, they are left with no identifiable target lesion to which their therapeutic intervention can ethically be directed.

My ontological position

I find it a true statement that the 'idea' of what we now refer to as subluxation within the discipline of Chiropractic is a timeless entity in spite of concerted attempts to debase it.

Our challenge is that nowhere over the time during which the idea of subluxation has been documented has there appeared a physical construct which could be replicated then falsified. The more ancient the documentation the more macroscopic the lesion until we reach today where we are talking about fine, microlevel characteristics. All denigration of subluxation is opinion, as is all praise. It has consistently been presented as a discreet dysfunction of some type, most often in the spine.

> I comfortably talk about the '*idea of subluxation*' based on a discreet dysfunction in the spine, which readily allows amplification of the clinical findings into a VSC. Things we do not know are what may cause this discreet dysfunction, and what may determine its expression, as in what determines the form of any physiological and material model it may take. (28)

An epistemology of subluxation

If ontology gives us an idea of what we are talking about, the nature or reality of the doable of subluxation, then epistemology gives the grounds of knowing what we can say about it. There are many epistemologies of subluxation and even more for the VSC. They help us investigate the nature,

sources, and limits of knowledge about subluxation. This is important to reference subluxation's limits and validity.

In simple terms, epistemology is the study of how we know what we know. (29) It addresses fundamental questions about what knowledge is, how it is acquired, and how we differentiate between justified belief and mere opinion.

> For the reason we build our epistemology of subluxation using unobservable phenomena such as the oft-stated 'nerve interference' we must use what Rosner calls '*surrogate measures*' and I call '*clinical findings*'.

When a patient presents complaining of headache a Chiropractor may say '*you have a subluxation in your neck*' which is opinion. On the other hand the Chiropractor could say '*let me examine you*' and in so doing establish a collection of clinical findings which create a clinical picture of things shown to be associated with the type of headache afflicting the patient. With finesse the Chiropractor could identify something through signs and symptoms localised to a particular segmental level of the patient's neck. In the AK paradigm for example one could use the ultimate indicator, manual muscle testing (MMT).

The need for a model

The next step is fitting this collection of clinical findings into a model held in the mind of the Chiropractor. When the pieces fall into place the Chiropractor can claim that

the things observed and documented fit into their model of subluxation.

From these heuristics comes the need for every student of Chiropractic to be taught one or more known models of subluxation in order for them to develop their own to be populated with found clinical data. Institutions which fail to teach students how to construct a model to organise the data they will collect during the assessment of the patient are failing in the most critical part of the Chiropractic curriculum. It is the model of subluxation which makes a curriculum a 'Chiropractic curriculum' and it appals me that educators may fail to understand this and thus fail to give the student their most important tool. Worse, most accrediting bodies do not identify subluxation as a learning object for students which might explain why so many academics are bemused by organisations such as the Council on Chiropractic Education Australasia (CCEA) who are quite good at accrediting therapy programs.

It is only when the model is created as an object in the mind of the Chiropractor that a segment-specific therapeutic correction can be created to best resolve the dysfunction and restore normal (for that individual patient) spinal function. Further, it is only when the adjustment has been delivered that there can be any outcome of care, and when this is documented it allows there to be a very strong presumption that the identified object held the characteristics of a vertebral subluxation.

This gives every reason to think that Palmer's protocol has been followed and that a subluxation has been identified and corrected and the patient is experiencing a health benefit.

Our individual epistemology

Epistemology examines the processes through which individuals acquire knowledge and assess its validity, it is the way scientific knowledge is validated through experimentation and peer review. Evidence is important, either primary or surrogate, in establishing truth. (29) Having said this, I appreciate Epistemological Relativism which claims that truth cannot be found absolutely, anywhere in human knowledge. And perhaps least of all about subluxation.

To help resolve this problem of 'no truth' we may resort to epistemic peers, who are people familiar with what we are trying to show. This is the window of revelation found in peer-reviewed, published case reports, but what happens when our peers disagree with the published findings, or even our own findings with a particular patient? Epistemological relativism suggests it does not matter and I have explained this in my perspectival truth paper. (5)

We move on to Epistemic Contextualism which is roughly the view that what is expressed by a knowledge attribution, a claim to the effect that S 'knows' p, depends partly on something in the context of the attributor. This is known as '*attributor contextualism*'. (30)

> In other words the Chiropractor knows 'p', in this case a place in a patient's spine where they believe there is a subluxation which matches their attentional template of subluxation, and is something they will clinically address with some form of correction.

This is a most reasonable position and one that allows Chiropractic as practiced by the 80% who hold conventional beliefs, to be a sound, evidence-based clinical practice.

Our greatest burden

The greatest burden on the discipline of Chiropractic is the expectation that, as a health science, it will 'fit' into the Western mould of evidence-based health sciences. I offer two observations:

1. The first is this should never happen, and
2. The second is why this should not happen, and the reason I propose is that Western health sciences are being forced into the pharmaceutical trial framework which was originally Epistemic relativism and more, imposed by Rockefeller and Carnegie through Abraham Flexner.

The prime driver for the Flexner report (31) was Rockefeller's ambition to make more money from his oil empire, (32) hence the petrochemical pharmaceutical industry was born (33) and sought to destroy natural medicine. (34) This happened within the first 20 years of Palmer's discoveries which remarkably withstood the onslaught of what has become Big Pharma. My position on this matter is grounded in historical reports and is not paranoia.

It was in 1996 that Sackett proclaimed evidence based medicine (EBM) as the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. (35) This statement has become an

epiphany for those wanting to denigrate subluxation because, paradoxically, they consider it absolves them from accepting Palmerian Chiropractic based on the discoveries of one man, notwithstanding the many refinements added by others since. It allows them the catch-cry of '*there is no evidence*' when the matter seems to be more that they fail to understand the very nature of evidence and that clinically, it is abundant. It is imperialistic to adopt Sackett's well-meaning statement of principle while ignoring its subtleties. (36) Worse, evidence-absolutists are even illiterate or in denial of the alternatives. (37, 38, 39)

I reject absolutist EBM

A number of problems are created the moment the principles of EBM are abused by evidence-absolutists. The first is conflict of interest and '*there is a … need to study hidden biases in sponsored research*'. (40) The second is more to do with the scientific proposition that a large cohort of subjects will even out the results and produce a finding that can be taken from the general and applied to one specific patient.

The world does not work this way, especially in personalised health care. This flow from the general to the specific results in under-determination by evidence; we have evidence from a group that lacks the power to determine what will actually happen in one individual. As Chin-Yee (41) explains '*EBM is unable to meaningfully test core medical beliefs that form the basis of our understanding of disease and therapeutics. As a result, EBM adopts an epistemic attitude that is sceptical of*

explanations from the basic biological sciences, and is relegated to a view of disease at a population level'.

The third and most concerning is the '*Fraud and Retraction Epidemic*' as explained by Castillo. (42) There is little protection against today's evidence being tomorrow's retraction. We needed trusted and validated sources to build our epistemic position.

The definitions which follow form a remarkable evidence base of things pointing to '*local doables*' (4) by a vast cross-section of the global profession. While none can be taken as describing the physical properties of a subluxation, they all provide a harmony of observable phenomena which point to '*something*' as being related or causative. It just so happens that in the greater majority of cases we should all be comfortable in calling that '*something*' a subluxation and, with its associated signs and symptoms, a VSC.

The fact that positive outcomes are reported by the patient when a precise therapeutic intervention is applied to correct subluxation continues to amaze me to the point that I wonder what the fuss is about when the post-realists get involved. (43)

Definitions are restrictive

Some are interested in defining subluxation being descriptive of the profession which it is not, rather it is a variable within the assessment of their patient. Variables carry a conceptual definition and an operational definition. The conceptual definition is the foundation of clinical practice because it describes what something *is* so that it can

be identified. The operational definition relates to *how* the variable is measured. So what it is that is being defined?

The question here is whether a Chiropractor's belief that they have identified something they can describe as subluxation is true or not; I maintain that it is true with the proviso that what they have identified may not have any physical characteristics to validate its existence. The simple finding that a vertebrae can be palpated and a judgement made as to whether it is behaving the same as those above and below can not be called a subluxation.

At best it is a vertebra with discernibly different palpation findings but this altered movement alone does not make it a subluxation. On the other hand it certainly makes it a candidate to be a contributor to a VSC and to show this, many more clinical findings must be gathered and related, shifting to an operational stance.

In other words the conceptual definition is very hard to match to physical parameters while the operational definition is a cinch with much clinical evidence being available, along with the ability to measure outcomes from the therapeutic intervention indicated by these clinical findings.

When all of these things align and the patient reports benefits to their health and well-being following correction we can apply Occam's Razor ('entities should not be multiplied beyond necessity') and suggest we have corrected a subluxation in this patient. It is the simplest answer as to why the clinical picture has changed.

> There are many who understand that, after Sandoz, (13) Smith and/or Gillet, (44) and Faye,

> (14) a palpable segment of the spine with fixation, so that it differs in its movements to those above and below, is most likely a subluxation. Holt et al (3) showed that Chiropractors can reliably find these but to the best of my knowledge nobody has yet shown that such a palpable lesion is irrevocably subluxated vertebrae let alone a Vertebral Subluxation Complex (VSC). There are no materialist measures that we can test with replication.

At best the agreement reached by Holt et al's subjects (3) is a clinical sign of something and this textbook is about better understanding what that 'something' might actually be or represent, with more surety that we can presently evince.

> Thus I contend that subluxation is a designate entity which is an unobservable phenomenon. (45) As Rosner notes we rely on surrogate measures and I hasten to add that these are very effective as the believed effects of subluxation, the surrogates, are most observable.

Chiropractic practice is strongest when it identifies these observable entities which collectively infer vertebral subluxation as a causative lesion. Leaving aside any complications of causation and/or association, it is these many observable clinical entities which construct the Vertebral Subluxation Complex about which Rome and Waterhouse are most compelling in their collected writings. (46)

Definitions are short-term

There are two lessons of value in the work of a group called Council on Chiropractic Practice (CCP) and their Clinical Practice Guidelines regarding Vertebral Subluxation in Chiropractic Practice. (47) The first is that there are some very serious and highly qualified people working towards a better understanding of subluxation, a finding I celebrate. They use appropriate techniques to search the literature and rank the evidence they find, giving an outcome of a detailed clinical approach to identifying subluxation. The second is that definitions are malleable and prone to change, something I struggle with and perhaps the reason I don't much like definitions.

The Foundation for Vertebral Subluxation's *White Paper* (48) talks of definitional drift and this is seen when we take the CCP's own 1998 definition …

> 'A subluxation is a complex of functional and/or structural and/or pathological articular changes that compromise neural integrity and may influence organ system function and general health'. (47 p. viii)

… and contrast it with their 2013 definition:

> 'Subluxation is a neurological imbalance or distortion in the body associated with adverse physiological responses and/or structural changes, which may become persistent and progressive. The most frequent site for the

> chiropractic correction of subluxation is via the vertebral column'. (49)

A strength of the revised 2013 definition is that it carries its meaning reasonably well when translated into other languages but the weakness remains in that it does not give any quantifiable physical dimensions, meaning its identification of subluxation is reliant on observable phenomena, is subjective, and may vary from Chiropractor to Chiropractor. In other words, it is a weak operational definition but to their credit, a strong conceptual definition with a listing of potential evidence to be gathered.

The problem

It is here that the 'subluxation problem' is seen most clearly: we have very detailed hooks on which to hang pieces of clinical evidence which collectively point to a treatable entity, a '*local doable*' but not a '*local beable*' as we still have no physical evidence of that specific entity. The enigma is that we continue to do something to it and the patient experiences a difference. The Pragmatic philosophical lens considers this a positive experienceable difference test.

To clarify this point, those readers who will claim findings from radiographs and motion palpation actually 'show' subluxation are in fact claiming illusions as their evidence; even these remain as surrogate measures of subluxation. As Holt et al (3) quite elegantly demonstrated, trained Chiropractors can agree on the location within the spine of a 'local doable' to be specific, in the cohort '*definite agreement occurred 63.3%*

of the time, possible agreement 19.0% of the time, and definite disagreement 17.6% of the time'. (3) It is well worth taking notice of this finding, it represents an 82% consensus that a doable exists and this level of agreement, >80%, amongst Chiropractors is more than acceptable. (50) I may be flawed in my seeking of evidence for a local beable, even though it is able to be cast as a doable.

I also note that the definitional 'change' or 'drift' between 1998 and 2013 given above is from the group from which some participants have produced the *White Paper*, (48) highlighting '*definitional drift*'. The finding that they have created definitional drift themselves suggests to me that drift to benefit evidence-based clarification is a good thing; when only reflecting opinion, it is not a good thing.

Does professional identity include subluxation?

Yes and no. As with definitions, professional identity is dependent on the group making the decisions. This is why there is a lot to like in Glucina's work (51) as it is based on scholarship, unlike the World Federation of Chiropractic's (WFC) Identity (52) which was based on consensus of opinion set at >80%. An 80% consensus agreement is indeed good and we should note Kamal's position that '*We seldom find a general consensus on anything in philosophy*'. (53) It is healthy to see 80%+ consensus in Chiropractic.

Glucina's found professional identity (51) included subluxation and allows the following:

> 'The belief of NZ Chiropractors is that their profession is strongly placed to provide care for adults and children and that the primary purpose of the Chiropractic exam is to detect vertebral subluxations. Chiropractors use an integrated approach to technique with the top 3 techniques used including Diversified, extremity, and activator instrument adjusting. Corrective and therapeutic exercises are also employed as well as neurological and Xray testing amongst others'. (51)

When subluxation is removed from the profession by its erstwhile notional global representative body, the WFC, (52) we see an organisation that is at war with itself, leading to a major nightmare at a global conference. (54, 55, 56)

When a mature analysis of the identity of Chiropractic is undertaken, as by Rosner in 2016, (57) we see he found, as did Glucina, that:

> [The] Identity of Chiropractic has been intimately associated with the Chiropractic subluxation.

Rosner admits that this is a topic of considerable debate within itself.

To the detriment of the global profession the WFC omitted subluxation from its Identity Process (52) which was undertaken over a decade before the Berlin fracas. Perhaps if the WFC had taken a sensible position and retained

subluxation within its manifesto it may have avoided the Berlin brouhaha. (54, 55, 56) The Identity Process was an expensive exercise where much effort went into due process only to be effectively changed after consensus was reached.

The WFC's Identity Process has the hallmarks of a marketing exercise to produce a generic identity for public use. The outcomes document warned '*It does not represent the full scope of chiropractic practice and should not be taken as a scope of practice statement, whether for educational, legal, practice, reimbursement or any other purposes*'. (52 cover notes) It created the position where subluxation was isolated from the identity of Chiropractic by purposeful exclusion from discussion, even though there is the anomaly of the finding that Chiropractors are '*Expertly qualified providers of spinal adjustment*', (52 4e) stated rather nonsensically in the absence of identifying anything to be 'adjusted'.

Whilst not directly related to definitions, the WFC Identity process carries the lesson that even when an expert panel makes its findings using due process, the body which commissioned the work is able to, after the fact, amend what has been agreed. This occurred when the WFC Council felt it knew better what 'the personality' of the Chiropractic profession should be and amended the panel's report to read '*Expert, professional, ethical, knowledgeable*' and '*Accessible, caring, human, positive*' with no reason being given. (52 p. ii asterisk)

The point I am leading to is that the following definitions of subluxation and/or professional identity which I now report only hold true for a short while because at best they represent a consensus of opinion of a small group of people at any one

point in time. The WFC went through a costly, detailed process to suit a political objective of having a customer-friendly identity which would not offend the WHO and which was amended after the event by just a handful of people, those who paid the piper really called the tune. We have seen that the CCP changed their 1998 definition in 2013 and perhaps this was to better reflect the evidence they were particular about documenting. We know Glucina reported the Professional Identity she found through painstaking doctoral thesis-level investigation of the profession in New Zealand, a process which to her credit is expected to be more stable and have a longer shelf-life.

A plethora of non-definitions

The most disconcerting aspect of subluxation is the plethora of non-definitions identified in 2024 by Rosner (58 pp. 45-51) and their smudging of the boundaries between being conceptual and operational. I consider them non-definitions because they give no measurable dimensions that can be falsifiable.

By now, those readers who are convinced subluxation is a thing that they frequently identify and correct will be annoyed with my insistence on having something material that I can teach to students of the discipline. It is not enough to list all the reasons why one calls what they palpate as a subluxation mainly because I hold this to be a perspectival truth; (5) this means I do not for one moment doubt they are palpating and correcting what they genuinely believe to be

a subluxation within a VSC with its attendant clinical signs and symptoms.

> My question is, what do I teach students new to studying Chiropractic about what they are expected to identify as their therapeutic target and then how do I reliably and repeatedly describe it both for education and public consumption?

It is evident that there is an inseparability between subluxation and Chiropractic and regrettably as Rosner (58 pp. 52-3) shows, some educational institutions deny this, as does the WFC, as discussed.

Rosner presents a significant piece of intellectual property (58) and it is not appropriate for me to simply give any of it here in a simple box, even with attribution. By way of ethical scholarship I will hold firm with persistent attribution to Rosner as I cite from his work to make my point of the variations in definitions. You may care to consider each as I give them and weigh-up their strengths and weaknesses. You can also look at the big picture and make a determination about definitional drift and whether it has any particular source beyond politics.

Extracts attributed to Rosner

Rosner cites The Canadian Chiropractic Association (CCA) as holding this definition of subluxation:

> 'Subluxation: A lesion or dysfunction in a joint or motion segment in which alignment, movement integrity and/or physiological function are altered, although contact between joint surfaces remains'. (58 p. 46)

The Australian Chiropractors Association adopted the World Health Organisation's definition of the subluxation which reads:

> 'A lesion or dysfunction in a joint or motion segment in which alignment, movement integrity and/or physiological function are altered, although contact between the joint surfaces remains intact. It is essentially a functional entity, which influences biomechanical and/or neural integrity' (58 p. 46)

The WHO also give this theoretical definition of a '*subluxation complex*'. (58 p. 50)

The New Zealand Chiropractors Association (NZCA) states:

> 'a vertebral subluxation is the impairment of optimal expression of your nervous system caused by physical, biochemical, or psychological dis-stress' and 'Chiropractors are highly trained health care professionals specialising in the analysis and correction of vertebral subluxations'. (58 p. 46, 47)

The NZCA's understandings are taken from material for the public and are quite extensive in their plain language explanations.

Rosner cites the General Chiropractic Council of the UK (GCC) as stating:

> 'The chiropractic vertebral subluxation complex is an historical concept, but it remains a theoretical model. It is not supported by any clinical research evidence that would allow claims to be made that it is the cause of disease'. (58 p. 49)

This denial by the GCC also represents academic censorship through their Forum of Chiropractic Deans, that subluxation may not be taught in any program of Chiropractic education that seeks accreditation by the GCC. (59) This overt censorship of academic freedom has gone unchallenged by the WFC and one can only wonder why. (60) A Forum of Chiropractic Deans (61) is reasonably expected to have a modicum of accountability given they hold responsibility to '*Enable patients, the public, health professionals, health & care organisations and commissioners to understand and recognise what chiropractors know and are able to do*'. (61)

The most vigorous and irrational denial of subluxation cited by Rosner is from Øystein Ogre, former President of the European Chiropractic Union, who for some reason claimed there are '*… similarities between the drawings of Mohammed, the burning of the Koran, the burning of the flag*' and subluxation-based Chiropractors. (60) Regardless of their past leader's

condemnation, common sense has prevailed and the ECU is promoting a short course to its members, '*the neurology of subluxation*'. (62) As I noted, definitional drift is political and it is not good enough for any profession to be reliant for its direction on the distorted dogma of any one 'leader'. The ECU is now also promoting Daniel Murphy's 'Subluxation Neurology' most likely in an effort to catchup with the rest of the world following Ogre vacating his leadership role. As cited by Rosner (58 p. 49, 50) Ogre claimed:

1. The subluxation has never been scientifically defined, tested, or validated.
2. There is no valid or reliable test to determine the presence or absence of a subluxation.
3. There is no valid test how to find a subluxation.
4. Chiropractors have never agreed upon a testable definition of what a subluxation is.
5. Other healthcare personnel don't understand what it is, and the public don't really care.
6. No one knows, except chiropractors, what a subluxation is.

Ogre's language is gruff and instead of listing six problems he could have been more of a statesman to not only have realised his points 5 and 6 are irrelevant, but to have proposed solutions to his other concerns. After all, at the time he was leading an association with the resources to implement reasonable research projects. Perhaps his view as a Chiropractor was muddled by his clinic group also providing physiotherapy, massage, acupuncture, and osteopathy.

The definition of the American Chiropractic Association cited by Rosner (58 p. 46) is weak and meaningless …

> 'Doctors of chiropractic are experts in the treatment of neuromusculoskeletal conditions, subluxation complex, biomechanical dysfunction, and disease'.

… and that of the International Chiropractors Association is not much better:

> 'The Policy Handbook and Code of Ethics describes the subluxation as causing "interference with nerve transmission and expression, due to pressure, strain or tension, upon the spinal cord, spinal nerves, or peripheral nerves as a result of a displacement of the spinal segments or other skeletal structures"'. (58 p. 45, 46)

The International Federation of Chiropractors and Organisations (IFCO) is a representative body of a number of association bodies and chiropractic organisations and Rosner shows only how they recognise subluxation. To give their definition I am reliant on their website: (63)

> 'A vertebral subluxation is an alteration of the intervertebral relationships of one or more articulations of the spinal column or the immediate weight-bearing components of the axial skeleton, accompanied by a change in the morphology of the tissue occupying the neural

> canal and/or intervertebral foramina; as well as an alteration of neural function sufficient to interfere with the transmission of organizing information, considered to be homologous to the mental impulse'. (63)

On the same webpage IFCO take another shot at describing a vertebral subluxation, saying:

> 'A vertebral subluxation is an alteration of normal spinal position, which, by the nature of the anatomy of the spinal column, will negatively impact the delicate nervous system tissues that travel through it'. (63)

When it comes to education, the Association of Chiropractic Colleges (ACC), (64) is cited by Rosner as holding that:

> 'A subluxation is a complex of functional and/or structural and/or pathological changes that compromise neural integrity and may Influence organ system function and general health. A subluxation is evaluated, diagnosed, and managed through the use of chiropractic procedures based on the most available rational and empirical evidence'. (58 p. 48)

The ACC bills itself as '*a collaborative member network of accredited Chiropractic education programs*' and its membership is 19 North American (US, Canada, Peurto Rico) institutions. (64) There are many more colleges outside North America

which lack a common association apart from the International Chiropractic Education Collaboration (ICEC) (19) which is a political grouping, and The Rubicon (22) which I consider more of a philosophical group. The purpose of ICEC is to act as a group dismissive of subluxation in the curriculum as shown by my previous discussion about CMCC:

> The teaching of vertebral subluxation complex as a vitalistic construct that claims that it is the cause of disease is unsupported by evidence. Its inclusion in a modern Chiropractic curriculum is anything other than an historical context is therefore inappropriate and unnecessary. (58 pp. 50, 51)

It seems that the signatories to that statement of denial are not actively enacting it within their curricular. Mirtz and Perle (65) reported '*Despite the controversies and paucity of evidence the term subluxation is still found often within the Chiropractic curricula of most North American Chiropractic programs*'.

A wider political view

At the time of writing, mid-2025, a newly elected President in the US was reviewing the government's various agencies and any impact on the following is not yet known. The Centers for Medicare and Medicaid Services (CMS) is a federal agency within the United States Department of Health and Human Services that administers the Medicare program and works in partnership with state governments

to administer Medicaid, the Children's Health Insurance Program, and health insurance portability standards.

Its relevance here is that part of its duties is to administer payments for Chiropractic services. Subluxation is a coded diagnosis in their Billing and Coding Services (A58412), and it exists in many forms in the ICD-10-CM. (66) Rosner writes that for 'diagnosis' the CMS states:

> 'The primary diagnosis must be subluxation, including the level of subluxation, either so stated or identified by a term descriptive of subluxation. Such terms may refer either to the condition of the spinal joint involved or to the direction of position assumed by the bone named. The precise level of the subluxation must be specified by the doctor of chiropractic to substantiate a claim for manipulation of the spine'. (58 p. 50)

Whilst I would argue that on its own, subluxation is a very weak diagnosis if it is a diagnosis at all, I would accept the situation that it is a term which must be used by a Chiropractor in the provision of a rebatable service to a patient covered by a particular health insurance scheme. If I were a Chiropractic student paying high fees for my education I would demand to be taught how to correctly use this diagnostic coding to ensure I was reimbursed and that my practice was ethical, moral, and legal. It seems that those institutions who have signed on to the ICEC position of refusal to teach subluxation

are placing their students at a significant disadvantage. Time will tell whether a class action arises.

The similarity in wording of the position held by the ICEC to the position of the GCC (given earlier) makes it clear that a lot of 'copy and paste' as plagiarism has occurred within the global academic community.

> It is inconceivable for a serious educational institution to simply adopt another institution's position especially to claim there is no evidence for subluxation in the absence of actually undertaking the scholarship to support that statement. Worse, the document from which they have performed 'cut and paste' even lacks attribution to the GCC. It is telling that not one of the signatory institutions seems to have undertaken the necessary scholarship and then published an independent, college-specific, evidence-based position.

I can only conclude that their relegation of subluxation to being just an historical concept and their stripping of it from vitalism represents plagiarised opinion, free of evidence and argument. Observers can only look at this with skepticism and come back to my opening proposition that definitional drift, including nullification, is political, and in this case lacking in any hint of serious scholarship. At best it results in reputational damage to those institutions too weak to form their own position.

In dramatic contrast there are institutions which take

the matter with due seriousness and I see this with Sherman College of Chiropractic. This institution has an active '*Center for Scholarly Activity … committed to improving the teaching and practice of chiropractic in a salutogenic, evidence-informed context focused on the analysis and correction of vertebral subluxations'*. (67)

The ICEC and the GCC are minority voices attempting to execute a fundamental change in the core premise of Chiropractic, an attempt at cultural reappropriation. Such a proposed change warrants rigorous analysis yet none has been reported, least of all from the academics of the copy-cat colleges.

An intriguing finding here is the role of Christina Cunliffe, Principal of McTimoney College. (68) Cunliffe is one of the three British academics asked for evidence of subluxation by the GCC and whether or not their institutions taught the concept. She reported: (69)

> 'The College [McTimoney] does not encourage the use of vertebral subluxation-centred models but rather draws out the problems with this model in the context of other approaches such as the biopsychosocial model. 'The College certainly does not teach that the vertebral subluxation complex is the cause of disease as this could not be justified on the clinical evidence"'. (69)

Cunliffe must be more a politician than an academic to have such changeable values. In 2010 she played a key role in

spiking the idea of subluxation within the discipline in the UK through her confidential report to the council of GCC from which the above is a verbatim extract, and by 2019 she and her institution are committed to the Rubicon Group (22) which strongly holds:

> '… that Chiropractic is a healthcare profession based upon a paradigm that includes:
>
> - a philosophy rooted in neo-vitalism
> - the traditional principles of Chiropractic
> - a neurologically-centred model of subluxation
> - a natural approach to health and well-being, excluding drugs and surgery'.

I commenced this chapter stating that the problem with subluxation is political, not scientific nor philosophical. I agree there is definitional drift for 'subluxation' and show that Professor Cunliffe OBE evinces this by stating a damning and negative position to the GCC while welcoming the opposite and embracing subluxation with open arms in the program of education she manages as a member of the Rubicon Group. (70) The puzzling question is not so much how Cunliffe can hold such conflicting positions, but more why her GCC-view has abandoned Palmerian principles, and is selective.

> As a resultant of Cunliffe's report to the GCC we see them dropping the idea of subluxation like a hot potato and censoring it from the Chiropractic curriculum in the UK while her college continues to say they teach it, while

> on the other we see Sherman College in the US actually doing the work around better understanding subluxation and more important, having processes in place to strengthen the teaching of 'subluxation' in its curriculum.

When an academic leader takes a position it is expected that they have evidence and that they are true to that position at all times. Cunliffe cannot be a trusted reporter to the GCC and lead her institution within the Rubicon Group at the same time; to do so would be duplicitous. However I question her report to the GCC as it has a significant internal contradiction. Cunliffe stated '*The College does not encourage the use of vertebral subluxation-centred models*' while her institution website states '*It [McTimoney] was formed to teach the Palmer principles of chiropractic*'. (71) If her Rubicon position is now her truth and if her institution does teach Palmerian Chiropractic then the very least she must do is to recant her evidence to the GCC and perhaps her OBE.

A reasonable position

An description not included by Rosner, perhaps due to its recency, is given as the position statement on the use of the term vertebral subluxation in chiropractic by the Canadian National Alliance for Chiropractic (CNAC). (72) It reads:

> 'The CNAC recognizes the value of the terms, "vertebral subluxation", "spinal subluxation", "subluxation" and "vertebral subluxation complex" when communicating, evaluating

> and delivering chiropractic care. The CNAC uses the term vertebral subluxation as a foundational cornerstone of the chiropractic care model to inform Canadians of all ages to advance their overall health and well being. This position aligns with the majority of practicing chiropractors who advocate towards the detection, identification and adjustment of the vertebral subluxation within their clinical approach and outcome assessments to determine care'. (73)

For the good of the discipline, this understanding should be adopted by all educational institutions, professional associations, and program accrediting bodies. Notably, the WFC should publish this position on its website, replacing the insipid 'Dictionary definition' dating from 2001. (74)

The bigger picture

In terms of the bigger picture I suspect the answer for why subluxation is a problem within Chiropractic lies in American chiropractic being more Palmerian while British chiropractic sits closer to bone-setting. (75) We see high denial of Palmerian values in the WFC and the British Chiropractic Association (BCA), the GCC of the UK, and with Ogre formerly of the ECU.

In contrast we see subluxation explained by Canadians as given above, and embraced in the American National Board of Chiropractic Examiners (NBCE), reported by Rosner as:

> 'The specific focus of chiropractic practice is known as the chiropractic subluxation or joint dysfunction. A subluxation is a health concern that manifests in the skeletal joints, and, through complex anatomical and physiological relationships, affects the nervous system and may lead to reduced function, disability, or illness'. (58 p. 51)

This aligns with the position of the ACC which is not surprising given the NBCE has inserted itself as the arbiter of Chiropractic education in the US. Yet we are left with a divide between this uniform North American view and the disparate British view. How can this be? I contend it is due to the GCC's position which is an error of both omission and commission.

Previously (76) I have shown '*That the position of the GCC on subluxation as "being without evidence and of value only in a historical context" is academic opinion presented in the absence of evidence*'. The error of omission occurred by action of the three academic members of the GCC Education subcommittee, Chiropractors Breen, Byfield and Cunliffe, who reported to the GCC '*unequivocal statements … to advise Council that the chiropractic vertebral subluxation complex is taught only as an historical concept, and there is no clinical research base to support the belief that it is the cause of disease or health concerns'.* (from GCC minutes 12 May 2010) This subcommittee was asked

a. How the chiropractic vertebral subluxation complex (VSC) is covered in the detailed curriculum; and

b. The relevant research they draw from.

The error of omission represents collective ignorance as academic leaders of programs meant to teach Chiropractic omitted to give any evidence for subluxation, including its historical use prior to Chiropractic, and that in their individual positions as academics that they had chosen to not include it in their curriculums, whether or not that was a true statement. This led to the error of commission by the GCC which occurred when '*By a show of hands, Council voted to accept the advice of the Education Committee and agreed to produce guidance on this matter, and to seek support from the chiropractic professional associations for compliance with the guidance'.* (from GCC minutes 12 May 2010)

In other words, the insular position of the GCC regarding subluxation is based on the opinions of three people who had each decided subluxation was not relevant to the curriculum for which each was responsible, and that it held no meaning for the students they were charged with educating. To my knowledge the truth of their statements has not been tested. The fact that one of the three is head of a college that states it teaches Palmerian principles of which subluxation and its correction is a foundational premise, is concerning.

The fact that a statutory authority blindly accepted opinion and made a decision which ignored the ample evidence available at the time (77) could be considered a significant failure of due diligence. The fact the GCC perpetuates its flawed position and does nothing to correct it demonstrates the degree of arrogance and intolerance associated with a bone-setter's mentality. This represents conceptual colonialism

where those with origins as traditional bone-setters (75) resist and defeat those with the training of a Palmerian Chiropractor to prevent colonisation of their crude bone-setting craft in the UK.

Why such variation?

When we take a serious look at the 19 examples given by Rosner (58), as much as I dislike definitions, and trace how subluxation is recognised globally we can draw two conclusions, which are contradictory thus anomalous:

a. subluxation is either addressed by the greater majority in a mature manner as integral to the practise of Chiropractic, in the clinical flow of ideas shown by me, (9) and emphasised by Vernon, (8) or
b. subluxation is rejected by a minority and not replaced with any concept that could represent a spinal lesion appropriate for therapeutic intervention in the manner expected of a trained Chiropractor. The GCC claim that there is no supportive evidence for subluxation is false, however their recognition of subluxation as holding an historical significance is true. The sadness is seen in this group's lack of scholastic ability to explore this to the depth it deserves which may in turn sharpen their focus on the role of subluxation in contemporary Chiropractic practice.

As noted in my companion volume to this textbook, (9 p. 1) a definition (as much as I dislike definitions) of Chiropractic which I accept is:

> Chiropractic is a paradigm of natural health care based on best evidence and historical efficacy concerned with optimising functional physiology and associated biomechanics of human movement supported by diet, exercise, and life style. Chiropractic centres on enhancing the body's neuromusculoskeletal systems.

This definition of Chiropractic, which I am not arguing to be right or wrong, does not mention subluxation, the reason being that I actually hold that Chiropractic as a paradigm of care can better be described and understood by making subluxation identification and correction central to the discipline, thus my statement of universal *meaning* as opposed to a definition, given again here as the combined ontology and epistemology of subluxation:

> 'The collective noun 'subluxation' is used within the discipline of chiropractic by chiropractors to predominately denote one or more clinical signs and symptoms evidenced on and by physical examination. Conceptualised as exhibiting elements of biomechanical dysfunction to variable degrees, subluxation may be identified in a specific joint complex of the spine, known as a 'spinal mobility unit', or other structures and is corrected manually using a hands-only controlled and rapid therapeutic thrust with intent. The thrust may be mechanically assisted. The outcome of such a correction is

> an adjustment of systemic neural tone which may be supported with lifestyle elements from nutrition to exercise.'

And here is where politics comes into play: I have shown the evidence to support my contention that politics is the problem. The political positions and phrases which do little to advance or clarify the term are those offered by a small regulator in Britain based on three Heads of Chiropractic education programs making a personal decision to eschew the term. Sadly we see a few institutions in other parts of the world plagiarise through 'cut and paste' the GCC position, adopting it without critical review let alone without supportive evidence. If what I am saying actually represents the situation then Chiropractic education is slipping into a very weak position where an institution puts itself in a position to fail to attract future students due to the institution choosing to remove the essential essence of the discipline they purport to teach.

> Every applicant to become a student of Chiropractic must satisfy themselves that the institution they are considering actually teaches the constitutional premise of the discipline, namely that subluxation exists, can be identified and corrected, thus allowing the body to move towards improved health and well-being.

These negative positions are extraordinarily poor in terms of scholarship, which is weak or non-existent, and this absence

of scholarship is a matter which should concern the profession as a whole.

These observations underscore the *White Paper*'s (48) position that definitional drift is political, a point I am eager to emphasise given it counters the GCC's political position of censoring the teaching of subluxation.

In trying to reconcile the finding that some institutions claim to be Chiropractic in nature while they omit the foundational concept of the discipline I am reminded of the view of well-known British marketer and advertising guru Rory Sutherland (78) who notes '*Things are not what they are; they are what we think they are*'. Are the post-realist (43) institutions which reject subluxation managing to survive because their fee-paying students *think* they are getting a complete education in Chiropractic?

Even those who reduce their practice or their teaching to simple force-based manipulation to address pain have significant gaps in their knowledge of how this may occur, (79) meaning they too suffer significantly from a lack of evidence.

Conclusion

The dominant force in Chiropractic is fragmentation. Not only of the idea of subluxation but of the very premise on which Palmer founded the profession, namely to be free of prescription medicines, surgery, poisonings, and burnings.

The profession suffers nascent intellectual eruptions that fail to move beyond passionate embrace of subluxation

correction as a universal elixir in the tradition of America's 19th Century cowboys and 'medicine-men'.

If the argument is not about a 'safety-pin cycle' after RW Stephenson (80 Article 38) then it is a pugnacious hermeneusis of DD Palmer's beliefs beyond his great discovery that this entity can be manually corrected with benefit to the patient; for some reason we seem to know more about the minutiae of Palmer's life than we do of either Jesus or Buddha.

The idea of subluxation and its effects within the VSC remains a rational postulate beset by incoherence, an orphan seeking a home. The *White Paper* (48) goes closest to showing what this home could be and it is now up to our academics to use the tools at their disposal to create and advance this 'home' on a global scale.

The profession remains conflicted between continuity and change. For its survival as a distinct paradigm of health and well-being it is imperative to ensure continuity of the idea that subluxation may affect health and well-being, while change within the profession must be positive and for the better understanding of the mechanisms involved.

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