

A Mathematical Basis for Defining Vertebral Subluxations and Their Correction

John A. Dulhunty

The concept of a "vertebral subluxation" has been basic to the chiropractic profession since its inception, and its correction remains a prime objective of chiropractic clinical endeavours. To many in the profession, subluxations form the link between chiropractic philosophy and clinical procedures. From an early stage in chiropractic development, there have existed two major concepts of what constituted a vertebral subluxation. One was static, using "listings" to describe the position of displaced vertebrae; the other functional, characterised by fixations and hypermobility. A third concept of subluxation was the medical use of the term. Medicine had regarded subluxations to be an incomplete or partial dislocation of a joint secondary to capsular laxity and associated with degenerative joint instability, profound trauma, or autoimmune disease. This concept did not embrace the chiropractic concept of nerve interference.

The original concepts underlying chiropractic subluxation theories have been widely questioned, modified or rejected by contemporary chiropractors. The legacy of the original subluxation concept remains in the form of principles adhered to by "straight" chiropractors, in techniques that still "list" the static position of displaced vertebrae, and general concepts and beliefs held by most chiropractors.

Keating¹ emphasises this point by stating, "Chiropractors, although unable to reach consensus on its definition and clinical significance, by and large accept that subluxations are real, that they can be detected, adjusted (reduced or eliminated), and that patient's health will improve as a consequence." He goes on to say, "Subluxation has become so overburdened with clinical, political and philosophical meaning and significance for chiropractors that the concept, which once helped to hold a young, besieged profession together, now threatens to strangle the discipline. The science and politics of the subluxation must be untangled."

The vertebral subluxation (fixation, misalignment, nerve interference) has been used as a rationale for manipulating the spine, while clinical and symptomatic changes (low back pain) associated with manipulation of the spine have been used to validate the existence of subluxations and the removal of nerve interference. Validation of one factor does not "prove" the validity of the other by implication. This is a fault in logic. Attempts by various authors to describe or demonstrate the characteristics of subluxations by associating them with manipulable lesions, somatic dysfunction and even osteopathic lesions, is an example of this type of reasoning. Charlton² defines the manipulable lesion as that "which can be explained as a clinically significant disturbance of joint movement or position which responds to manipulation." He then equates this with the subluxation by stating, "Chiropractors, the largest group numerically in the field of manipulation, have, since the turn of the century, called this entity 'vertebral subluxation.'"

This association has been rejected by other authors, researchers and even other professions. Keating¹

believes, "We are not yet able to relate palpable and manipulable lesion to subluxation theory."

Brantingham³ states that osteopathy and manual medicine "do not use this (subluxation theory) as the only concept, or primary etiological description of the manipulable lesion." He concludes that "Research and available literature make it clear that the manipulable joint lesion and subluxation are not synonymous." The New Zealand Commission of Inquiry⁴ in their report state, "It is clear that the general concept of the 'chiropractic' subluxation is not accepted by medical practitioners." Hubka⁵ suggest that "problems occur when this term (subluxation) is used to describe the manipulable lesion." Kirkaldy-Willis and Cassidy⁶ also have reviewed the literature and in summation state that, "at present there is no evidence that manipulation replaces subluxated vertebra." White and Panjabi,⁷ under the heading of "Spinal Manipulation," quote from the editor's summary of the Research Status of Spinal Manipulative Therapy proceedings of the 1975 workshop sponsored by the National Institute of Neurological Diseases: "There was no quantitative or qualitative reproducible description of subluxation either mechanically or anatomically. The concept of chiropractic subluxation remains a hypothesis yet to be evaluated experimentally. We believe that this has been one of the most frustrating aspects of certain views of the pathology that is purported to be altered with spinal manipulative therapy. When one is correcting a 'subluxation' that cannot be perceived by independent observers, it is difficult to convince those observers that the treatment is effective." Charlton,² when assessing the accuracy of methods for demonstrating subluxations is forced to conclude "that any group of examiners agrees on findings does not address the ultimate question: even if they can agree, does anything they agree upon actually exist?"

Evidence, such as the Meade study⁸ supporting the efficacy of the chiropractic approach to back pain and other symptoms, does not "prove" the existence of the vertebral subluxation. Attempts to associate chiropractic techniques such as manipulation with subluxations, as well as being logically flawed, are also brought into question by clinical studies. Keating¹ quotes several studies that "have suggested potentially subluxation-independent effects of the high velocity, low amplitude, thrust stimulation chiropractors use." He further states, "These investigations suggest (but do not prove) that there may be useful local and systemic effects of adjusting spinal joints, effects which may be achievable whether or not a subluxation can be detected, reduced, or eliminated."

A major factor hampering attempts to validate chiropractic concepts is the assumed philosophical and clinical association between three components of the chiropractic subluxation hypothesis. These components are the mechanical subluxation (spinal lesion), neurological subluxation (nerve interference) and the manipulable subluxation (adjustment). These three components have been considered by many chiropractors to be essential ingredients of a single entity. To have the concept of a vertebral subluxation accepted as a scientifically verifiable entity and gain general agreement on a definition, there is a need to dissociate the concepts of the subluxations as an entity, neurological involvement as an effect, and spinal manipulation as a treatment. If the subluxation is defined in absolute terms, treatment modalities, such as manipulation, are the variable, and their efficacy must be proven. The optimal treatment of such an entity may or may not include manipulation. Conversely, if manipulation is established as an effective treatment for specific symptoms or for restoring function to the spine, the diagnostic criteria and symptomatic patterns that represent the manipulable lesion must be established. This may or may not include subluxations.

As a response to criticism and limitations inherent in the original subluxation concepts, many chiropractors have suggested expanding the concept of a subluxation to embrace the more diverse

"vertebral subluxation complex" (VSC). Even though the VSC is based on pathological principles, it fails to identify the relationship between components, the core component, or specific nature of the subluxation. The factors that form the VSC can apply to any pathological change in any system of the body. The VSC, like a footprint, serves to signal the presence and effect of a subluxation, but not its nature. A disease entity such as diffuse idiopathic skeletal hyperostosis (DISH) could be described using the five components that comprise the vertebral subluxation complex (including kinesiopathology and neuropathology), without being classified or commonly accepted as a subluxation. It is difficult to gain from the literature relating to the VSC if the primary object of treatment for the vertebral subluxation complex is the removal of "nerve interference" (neuropathology), normalisation of movement (kinesiopathology), correcting misalignments (positional dyskinesia), muscle balancing (myopathology), the treatment of inflammatory response with drugs (biochemical changes) or the relief of symptoms by manipulation (medicine). It is Dishman's⁹ conclusion after reviewing the literature that there is a need to show the "subluxation complex as a distinct clinical entity comprised of five components all related to a pathomechanical disease cycle." It is the nature of the pathomechanical element that remains elusive and controversial.

The key to understanding the concept of what chiropractors call subluxations is to realise that "subluxations" do not exist. There is no single physical entity that can be exclusively described as a "subluxation." They do not physically exist in the same way that bones and muscles exist. A subluxation is a mental construct, just as the north pole is not a physical pole, but a theoretical concept, and the equator is not a line around the earth. The border between states is not a line on the ground, only an imaginary boundary, even though it may be based on geographical features. In the same way the concept of a subluxation may be based on physically recognisable and measurable qualities (fixations, misalignments, etc.), but the grouping of features into the single concept of a subluxation exists only in the mind of the observer.

Subluxations gain their existence from mutually agreed inclusion criteria and the demonstration of usefulness of the grouping. Subluxations are not in spines waiting to be discovered like nuggets of gold in the ground. Paraphrasing Barlow,¹⁰ "what chiropractors call subluxations are states of functioning of many people, no two alike, but similar enough for general concepts to be formed." They are the grouping of patterns in many spines that possess common clinical, functional, or structural features that have been accepted as a subluxation.

The usefulness of that grouping requires clinical trials and epidemiological studies. It also depends on the ability of the proposed groupings to describe common features, predict the course of the condition (prognosis), and act as an effective prescription for treatment. Chiropractic philosophy and clinical experience suggests that a mechanically- based vertebral subluxation hypothesis is a clinically useful concept that would be unique and distinct from other disease, pathological or clinical entities. For the concept of a vertebral subluxation to have more than historical value and provide clinically useful information for the chiropractic profession, its ability to be descriptive, predictive, and prescriptive needs to be critically evaluated using scientific disciplines rather than dogmatic assertions.

The solution to the political, clinical, educational and research needs of the profession in relation to the vertebral subluxation is to construct a concise definition or model that is specific enough to provide objective evaluation of spinal pathomechanics, yet generalised enough to facilitate a wide range of problems encountered in clinical practice. The definition should provide an accurate description of spinal changes ranging from global postures to microscopic changes. It should also encompass static evaluation (positional dyskinesia), and changes in mobility and axes of movement

(kinesiopathology).

Each discipline in the health sciences gains validity and investigative protocols from one of the basic sciences. Mechanics, a sub-branch of physics, is the science concerned with the position and movement of objects, and the forces that influence them. Many attempts to define vertebral subluxation have made reference to spinal biomechanics and pathomechanics without specifying the meaning and implications of the terms. Mechanics is a scientific discipline with well established terminology and concepts that are useful in understanding the normal and abnormal spine, if correctly applied.

There are three qualities fundamental to mechanics: length, force and time.¹¹ From these factors there are derived qualities that can be employed to describe, qualify and quantify the vertebral subluxation in terms that are recognised and accepted by the scientific community. The advantage of defining a subluxation in mechanical terms rather than physiological, structural (anatomical), pathological, or therapeutic terms is that the subluxation can then be expressed in numbers and utilise mathematical and mechanical equations and concepts. As Dishman says, "Science is valid measurement."¹ The first problem for the chiropractic profession is knowing what to measure (definition); the second problem is how to measure it (clinical application).

Having the subluxation based on mechanical principles necessitates the application of the fundamental qualities of mechanics to the spine (distance, force and time). The derived qualities of displacement, load and resistance must be known or calculated to describe the subluxation accurately and completely. Because these three factors are all related and necessary, any one could be used as the primary subluxation factor. Historically and semantically the term subluxation has a positional connotation. For this reason the loss of mechanical integrity of the spine is expressed in terms of displacement. The subluxation is defined in mechanical terms as a loss of positional integrity in the spine.

Positional integrity can be defined as the normal static and dynamic relationship between or within elements of the spine. It involves displacement, deflection, and deformation which are the mechanical terms referring to the reaction of a structure or tissue to an applied or external force.

To express and evaluate a loss of positional integrity of the spine (subluxation) in mechanical or mathematical terms, knowledge of two of three related fundamental quantities are required, from which the third can then be determined. The three factors of load (force), resistance (rigidity) and distortion (form), interact with a fourth factor (time) to produce further derived quantities. These derived quantities include creep; hysteresis; stress relaxation; and the rheological properties of viscosity, elasticity, plasticity, and strength. Biological structures can be understood in terms of their mechanical properties with the behaviour of materials expressed as stress/strain curves and structure as load/deformation curves.

Deformations within the body, from microscopic crystalline structures to macroscopic postural changes, can be described mathematically by defining any point in the body by its position vector in a coordinate system. Displacement vectors can represent changes in position (linear and rotational.) The cause of a positional change in the spine (subluxation) in mechanical terms is due to a change in the applied force (load= L) and/or a change in resistance (R) over a given time (t). This can be represented by the formula $D=L/R(t)$. With this formula the emphasis for the chiropractic clinician and researcher changes from finding or locating a subluxation, to the application of the principles of mechanics to the

spine to analyse its integrity.

Reducing natural phenomena to mathematical formulae, such as Newton's laws of motion, does not alter the way the physical world works, nor does it restrict the use of force to only those who understand those laws. What mathematics can do is expand and make clear the principles underlying observed phenomena. This not only has the potential to strengthen present chiropractic concepts, but also to promote the application of advanced mathematics (calculus, computer modeling, catastrophe/chaos theory) to spinal function. Mathematics should not detract from the art or philosophy of chiropractic, but add to the science. Even though Newton's laws allow an accurate prediction of the flight of a baseball, they do not detract from the atmosphere and art involved in hitting a home run in the World Series. The formula used to define the subluxation does not necessarily make it easier for the clinician to detect and measure the subluxation; its aim is to provide understanding of the nature of the subluxation.

An advantage of describing a subluxation in mechanical terms is the potential to unify the many seemingly divergent concepts regarding the subluxation within chiropractic. The debate whether the subluxation is a change in function (mobility) or position (misalignment) is meaningless in the context of biomechanical principles. Both approaches represent an assessment of where a particular vertebra is in a given situation (standing posture, point in a range of movement, etc.). All functional patterns in the spine can be accurately described and assessed as an interaction between load and resistance measured as a change in positional relationships between spinal structures. Chiropractic analytical procedures, including motion palpation, generally evaluate where segment is, not how it got there.

A predominant factor in defining a subluxation is the relevance of the grouping to a proposed treatment strategy, or its usefulness in setting parameters and protocols for treatment. It would be inappropriate to define a subluxation in biochemical or neurological terms if the proposed treatment does not directly restore normality to these factors. Many contemporary chiropractic techniques employ an external force as a means of correcting what they consider features of vertebral subluxations. These techniques involve forces producing a push, pull impulse, vibration, etc., through manipulation and mechanical devices (Activator, drop table and blocks, or traction). While a vertebral subluxation may be quantified and qualified using a variety of clinical techniques, the concept should be specific enough to set general treatment parameters, and treatment objectives. If "nerve interference" is included in the definition, a direct or reliable measure of its reduction or removal is necessary to provide a meaningful assessment of treatment efficacy. Treatments that have no meaningful or reliable assessment criterion, whether medical procedures or vertebral subluxations, must remain unsubstantiated and can be stigmatised as dogma.

If the expanded concept of positional integrity embodied in the subluxation formula is accepted as the prime indicator of spinal integrity, chiropractic treatment can be quantified and qualified using the reduction or correction of the subluxation factors as the criteria. Chiropractic treatment, including manipulation, can be objectively assessed not only on the ability to alter symptoms such as lower back pain, but also the ability to restore positional integrity to the spine. This in turn allows the determination of the efficacy of treatment, scope of practice, and outcome assessments based on objective criteria without the need for arbitrary restrictions. An adjustment in the context of the subluxation model is the reduction of subluxation factors to or toward normal. The force required to correct a vertebral subluxation can be expressed using the mechanical concept of work that includes the same factors as the subluxation formula, i.e., $L(\text{force}) = D \times R(t)$. Manipulation is one means of achieving this. A treatment in this context, as opposed to an adjustment, would be any therapeutic

intervention aimed at reducing or removing symptoms. Manipulation could still be an effective treatment for back pain without having been shown to reduce or remove subluxations.

Traditional chiropractic subluxation concepts involving pathomechanics, whether fixations or misalignments, are inadequate in describing the dynamic (time-related) changes that occur in the body as it attempts to maintain homeostasis and environmental adaptation. To be truly dynamic the subluxation model must contain a time component and be integrated into a dynamic feedback mechanism. Biomechanics as a branch of science includes a time function that gives the subluxation a dynamic component and predictability lacking in more static definitions. Faye is credited with introducing what he called a paradigm shift¹² by expanding the vertebral subluxation to include the elements of the vertebral subluxation complex (VSC) and motion palpation. This paradigm shift still encompassed a static notion of the spinal lesion, in that the positional concepts of Palmer were replaced by motion palpation, but still lacked a time component. To call what chiropractors refer to as motion palpation or kinesiopathology, "dynamic" is a misnomer and of limited value in mechanical terms.

An important consideration in developing a functional subluxation model is recognising the feedback mechanisms that make vertebral subluxations part of a dynamic living system. The subluxation is one factor in a complex system and presenting it as a cause of "dis-ease," nerve interference, or any other symptom restricts the subluxation concept to a simplistic, linear, cause and effect type relationship that does not represent the way the body functions in health or disease.

The philosophical concepts inherent in the definitions endorsed by various groups within chiropractic would suggest a direct relationship exists between the number and magnitude of subluxations, and the extent and magnitude of "nerve interference" with no reference to time, healing, or adaptive processes. The body consists of complex positive and negative feedback mechanisms that help maintain homeostasis, such as the piezoelectrical effect that helps remodel bone. These mechanisms help the body deal with stress and adapt to the external environment. They apply equally to the mechanical factors involved in subluxations. Relating this to chiropractic philosophy, innate is not blind to the subluxation. In this context a subluxation can be both a cause and effect, with abnormality becoming normal with time through adaptation and self-healing mechanisms, and vice versa. (Fig. 1)

For the 100 years chiropractors have been looking to the spine for functional states and structural changes that could be described as subluxations or offered as a rationale for manipulation. The scientific discipline of mechanics allows chiropractic to define the subluxation in mathematical terms using the formula $D=L/R(t)$. A subluxation is not the same in a child as in an adult. It is not the same following trauma, injury or disease when spondylitic changes or disc degeneration has occurred as it is after acute injury.

The subluxation that is present today, if untreated, will not be the same a year hence. If there is a commonality of factors, it is not the misalignment, fixation, nerve interference, symptoms, or something the chiropractor can feel. The common feature is a loss of mechanical integrity of the spine expressed as positional change through the subluxation formula, and incorporated in a dynamic subluxation model. This approach offers the chiropractic profession a comprehensive yet flexible and nondogmatic format that has the potential to modernise chiropractic theories and give the vertebral subluxation a scientific basis without compromising the profession's philosophical heritage.

The concept of spinal displacements, whether positional or functional, is not new to chiropractic. What

is new is combining the four mechanical factors of load, resistance, displacement and time into a comprehensive, integrated mathematical formula representing the vertebral subluxation. This theoretical formula can be used as a foundation for research into locating and correcting subluxations, and validating and improving chiropractic clinical procedures.

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John A. Dulhunty, DC
Coffs Harbour
Australia

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