V. Definition of Subluxation and Average Normal Spinal Alignment

RECOMMENDATION

Vertebral subluxation should be maintained as the primary health disorder that comprises the Chiropractic professions identity. The 6 structural categories of subluxation presented herein are recommended descriptions for the biomechanical component of vertebral subluxation. Radiography is indicated for the qualitative and/or quantitative assessment of the biomechanical components of these 6 vertebral subluxation categories. When using radiography, a baseline value of the mechanical displacement should be determined prior to the initiation of chiropractic treatment intervention. In this manner, response to care can be determined.

<u>Supporting Evidence</u>: Systematic Literature Search, Professional Surveys, Population Studies Class 2-4, Basic Science, Biomechanics, and Validity.

<u>PCCRP Evidence Grade</u>: Population Studies = b, Professional Surveys, Basic Science, Biomechancis, and Validity Studies = a.

Introduction

Historically, there have been many different definitions of vertebral subluxation used by chiropractors and other health care providers. A commonality of chiropractic definitions has been: 1) vertebral misalignment and 2) disturbance of normal nerve function.

In general, chiropractors have long been displeased with the medical profession's definition of subluxation, which usually has had something to do with translations of single vertebra beyond the limits of the spinal ligaments; i.e., retrolisthesis, laterolisthesis, and thin discs. As an example, the Cervical Spine Research Society defined spinal subluxation as a "nontraumatic condition caused by approximation of vertebrae due to disc degeneration, with concomitant telescoping of articular processes without disruption of joint surfaces" (1983).[26] In some texts, 3 or more millimeters of translation are considered an indication of spinal subluxation. Mechanically, translations are only 3 of the six possible degrees of freedom of spinal motion.

To quote White and Panjabi's 1978 text, "Subluxation may be defined as a partial dislocation. It is any pathological situation in which there is not a normal physiological juxtaposition of the articular surfaces of a joint. Such situations should be reliably demonstrable radiographically."[29] This definition implies ligament disruption. When ligament disruption is the only definition of subluxation, then smaller displacements within the range of joint motion, maintained for long periods of time, are eliminated from consideration even though serious soft tissue deformations may result and pathologies created. Also abnormal postural positions and their consequent spinal coupling patterns, which are associated with asymmetrical spinal loading and pathologies over time, are eliminated as possibilities from this White and Panjabi definition.

A review of a few chiropractic definitions does little to clarify the entity of subluxation. For instance, the following persons and groups have all defined subluxation differently: D.D. Palmer,[24] B.J. Palmer,[25] Janse,[16] Lantz,[18] Yochum and Rowe,[30] Harrison et al,[5] Osterbauer,[31] Bergmann and Finer,[32] Cooperstein and Lisi,[33] Owens and Pennacchio,[34] Triano,[35] ICA,[14] ACA,[1] Hildebrandt,[12] Gatterman,[4] and the 1972 Medicare Huston Conference.[13] The Houston Conference was composed of members from the liberal Chiropractic Colleges (ACA affiliates in 1972), DACBRs, and DACBOs. They defined subluxation as, “the alteration of normal dynamics, anatomical, or physiological relationships of contiguous articular structures.”[13] We note that they added “dynamics and physiological relationship” to the “alteration of anatomical relationship” used by the conservative colleges (ICA affiliates in 1972).

In general terms, instead of a precise definition of subluxation, chiropractors have resorted to vague terms such as “biomechanical aberration” and “loss of mechanical integrity of the spine” and have attempted to describe the effects of subluxation, such as “histopathology, myopathology, kinesiopathology, pathophysiology, and neuropathophysiology.”[18]

In July 1996, spinal and extraspinal subluxation was defined through consensus of the chiropractic college presidents: “*Subluxation is a complex of functional and/or structural and/or pathological changes that compromise neural integrity and may influence organ systems function and general health.*”[27]

However, the past editor of Journal of Manipulative and Physiological Therapeutics, Dr. Lawrence stated, “*Subluxation goes beyond metaphor; it is at the heart of chiropractic. This being the case, we must follow where our studies take us, never fearing to modify our core beliefs even when it affects market share or reflects poorly upon our science. Science is mutable; it changes with new data. So, too, does the chiropractic profession. Efforts to better define and understand the subluxation can only help but take us into a brighter future,”*[19] and “*Attempts to define the term (subluxation) are regularly made, only to fall afoul of political considerations rather than scientific ones.*”[19]

Thus, in the opinion of the current panel of experts, the definition of subluxation by a consensus of the chiropractic college presidents is another definition of subluxation that falls short due to an all encompassing political net and a more scientific approach needs to be considered. The need for a more scientific definition is vital when radiography is utilized as a measurement of spinal subluxation.

Attributes of Spinal Subluxation

In 1997, Nelson[20] wrote a critique of several attempts to define subluxation. He pointed out that, “at no point is there a statement or observation that a subluxation is a particular alteration of anatomy, physiology, etc.” Nelson also stated that attempts to change the name (of subluxation) to “manipulable lesion,” “loss of function,” etc. are semantic issues, when the real issue is “whether the concept of subluxation is valid and represents a clinically important phenomenon.” Also Nelson[20] stated that a theoretical model of subluxation should do at least three things: 1) A theory should attempt to explain existing phenomena and observations; 2) A theory should make predictions; and 3) A theory should be testable or falsifiable. He[20] listed 6 attributes that a definition of subluxation must have:

1) It should have some resemblance to its historical antecedents;
2) It should be testable;
3) It should be consistent with current basic science precepts and principles;

4) It should reflect current practice and educational standards (specificity);
5) It should be clinically meaningful (tangible clinical consequences); and
6) It should present a distinct and unique point of view.

Nelson[20] also noted that "spinal lesion" does not fit the requirements. Webster's defines "lesion" as a) "injury" or b) "an abnormal change in structure of an organ or part due to injury or disease." Thus, lesion (injury) could be the cause of a subluxation or the result (disease) of a subluxation, but does not state what a subluxation is.

Also, it should be noted that several College administrators and faculty[17] have stated that there is no such entity as a vertebral subluxation and the term should be discarded. However, over the years, the ACA (SOS campaign = Save our Subluxation) and ICA have always reaffirmed the use of the term vertebral subluxation.

According to a 2003 study on "How Chiropractors Think and Practice: The Survey of North American Chiropractors," published by the Institute for Social Research at Ohio Northern University, "*For all practical purposes, there is no debate on the vertebral subluxation complex. Nearly 90% want to retain the VSC as a term. Similarly, almost 90% do not want the adjustment limited to musculoskeletal conditions. The profession -- as a whole -- presents a united front regarding the subluxation and the adjustment.*"[115]

Below we will provide an updated scientific definition of 6 different structural subluxation classifications that will satisfy Nelson's 6 attributes and it will be historically and contemporarily correct. Furthermore, it will be shown that spinal radiography (or other advanced imaging techniques) is the only valid means to assess the presence and magnitude of these 6 structural subluxation classifications.

Definition of Subluxation from the Practicing Chiropractors Committee

It is the opinion of the PCCRP panel that practicing Chiropractors have defined subluxation, used it daily in their assessments, in their corrective adjustments and rehabilitative procedures, and in their explanations to patients since 1910. Any definition of subluxation should include the historical concepts used by Chiropractic Clinicians, should be consistent with mathematics and mechanical engineering principles, and it should be valid in terms of the known spinal sciences.

It is the consensus of this panel that the original definition of subluxation derived from the Palmers[24,25], "*a bone that has lost its normal juxtaposition causing nerve interference*", is what Chiropractic Clinicians have used daily for approximately 100 years. We will show that this historical "working definition" of subluxation by practicing Chiropractic Clinicians satisfies Nelson's 6 attributes described above, it is mathematically sound, it is based upon mechanical engineering, it is supportable with current spinal sciences, it is measurable, it is correctable (if degeneration or deformity have not progressed too far), and it will include the specific types of subluxations listed by the Houston "Medicare Conference" in 1972, which derived our Medicare listings for the US Federal Government.[13] Thus, this subluxation definition, "*a bone that has lost its normal juxtaposition causing nerve interference*", is simple, partly used already in Federal Guidelines, and it is scientific.

In this section of this Radiological Protocol, we will discuss "Bone out of Place", but in Sections X & XII of this document, which discusses predictive validity and tissue mechanoreceptors, will be the primary supporting evidence for the statement that "Bone out of Place has inherent functional disturbances and nerve interference".

The immediate need in this section is to define what it is that Chiropractic Clinicians will be assessing via spinal radiography. To begin, a normal average spinal alignment from which measurements of subluxation can be determined is needed. This comes directly from the fact that "Bone out of place" begs the question what is meant by "in place"?

Average Normal Spinal Alignment

Most health care providers accept the average values as "Normal" from a plethora of physiologic, anatomic, and biomechanical measurements (such as normal blood pressure is 120/80). Similarly, average values as "Normal" from healthy subjects for spinal alignment have been determined and published in the scientific literature. Because an average normal spinal model for each region (cervical spine, thoracic sine, and lumbar spine) was not published until recently, the Chiropractic founding fathers did not have access to any such normal values of segmental and/or global alignment. Thus they had only their intuition to guide them. However, this information is available to us at the present time.

From 1996-2003, normal spinal models were published for each region of the spine.[6-11,15] These normal spinal models are of **two types**, ***average***[6-8] and ***ideal***.[9-11,15] These models have been criticized by persons denying the very existence of subluxation, and have been suggested to be solely ideal or theoretical in character without clinical utility.[21,22,28,36,37] However, **average normal** spinal models have been developed and published in scientific journals. Furthermore, criticisms addressing these models have been addressed and adequately refuted.[6-8,38]

In these recent modeling studies of normal individuals, subject x-rays were placed on a view box where a sonic digitizer was used to touch the vertebral landmarks on the x-ray. Specifically, the x-y coordinates of the posterior aspect of the vertebral body landmarks are read and stored in a computer data base. These x-y coordinates from digitization of subject films, are then used in modeling of subject spinal alignments. As a result of this 'curve fitting modeling process', pieces of circles and ellipses were found to closely approximate the alignment of the posterior body margins and thus this average normal spinal model is actually the path of the posterior longitudinal ligament (PLL) from C1-S1 (Figure 1). It is important to note that chiropractors are not the only health care clinicians that are interested in average models of the spine. Recently, orthopedic surgeons have developed an optimization approach to model subject specific sagittal plane spinal curves; application of these models to spinal pain/deformity groups is being done as well.[39-42]

Before presenting average normal values for each motor unit (two adjacent vertebrae), we note that these average normal models have predictive validity in as much as they can discriminate between normal subjects, acute pain subjects, and chronic pain subjects in both the cervical[8] and lumbar spines.[6]

In the AP/PA view, the spine should be vertical and all end plate lines should be horizontal including occiput, C1-C7, T1-T12, L1-L5, sacral base, and a line at the tops of the femur heads (Figure 2A). These lines are the Gonstead Technique[43] wedge lines or also they are the endplate lines from which perpendiculars are drawn in the Cobb analysis, i.e., all wedge lines are parallel and all Cobb angles are 0º in the AP or PA spinal radiographic view. Another way to express this AP vertical alignment of the vertebrae is to state that all centers of mass are vertically aligned. In the cervical spine, this is equivalent to stating that the upper angle, lower angle, and CD angle on the nasium view are 90º, 90º, and 0º, respectively (See Section X Nasium X-ray view). In the thoracic and lumbar spines, this is equivalent to stating that all AP Riser-Ferguson angles (in any spinal region) are 0º (See Section X AP Thoracic, AP Lumbar, and AP Ferguson X-ray views).

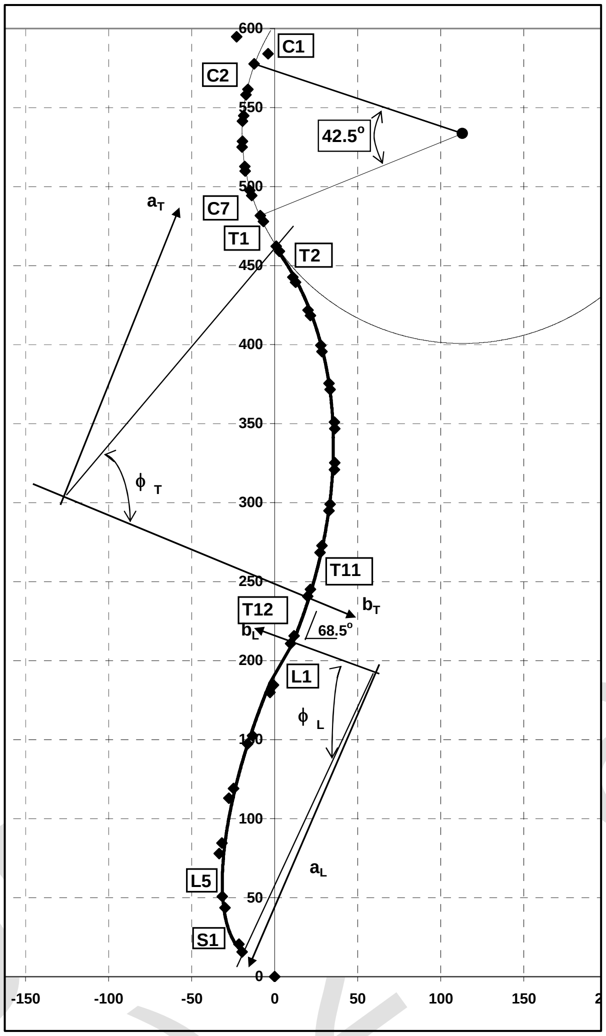

Figure 1. The 2003 Average Normal full Spine Model from C1 to S1 is the path of the PLL. The points shown for C2-S1 are the posterior vertebral body corners. The average normal full-spine model from C1 to T1 is composed of two C1 points (mid anterior arch & mid posterior margin of lateral mass) added to the C2-T1 circular model in Spine 2004. This C1-T1 model is added to the T1-T12 model by superimposing T1. Then the T12-S1 model is added, (from the Journal of Spinal Disorders). The resulting model has near perfect sagittal balance of C1-T1-T12-S1. The vertical line (VAL) for determining sagittal balance is drawn through the origin at posterior-inferior S1. Since a circle is a special ellipse with b/a = 1, this new full-spine model is composed of ellipses in the cervical, thoracic, and lumbar regions, but of different b/a ratios and different height-to-length ratios. It is understood that if an AP alignment of the posterior bodies was illustrated, then the spine in the AP view would be straight or vertical. [Reprinted with permission: Harrison DE et al. Spinal Biomechanics for Clinicians, Vol I., Evanston, WY: Harrison CBP Seminars, 2003].

In the sagittal view, average normal rotation angles of each motor unit (two adjacent vertebrae) can be derived from drawing lines along the posterior body margins of every vertebrae and measuring the angle of intersection of each pair (Figure 2B). In actuality, these lines represent the slopes in an Engineering analysis of structures taught in Mechanics of Materials.[2] For C1, the sacral base (S1), and the pelvic tilt, lines through these structures are often compared to a horizontal line for an angle of inclination in degrees (Figure 2B). Segmental angles formed at adjacent vertebrae are termed Relative Rotation Angles (RRAs), while global angles (Absolute Rotation Angles are termed ARAs) in each region can be formed by comparing a superior vertebra in a sagittal region to an inferior vertebra. In this way an evaluation of the cervical lordosis (ARA C2-C7), thoracic kyphosis (ARA T1-T12 or ARA T2-T11), and lumbar lordosis (ARA L1-L5) can be measured in degrees. The reliability of these x-ray mensuration procedures will be comprehensively reviewed in Section VIII of the document.

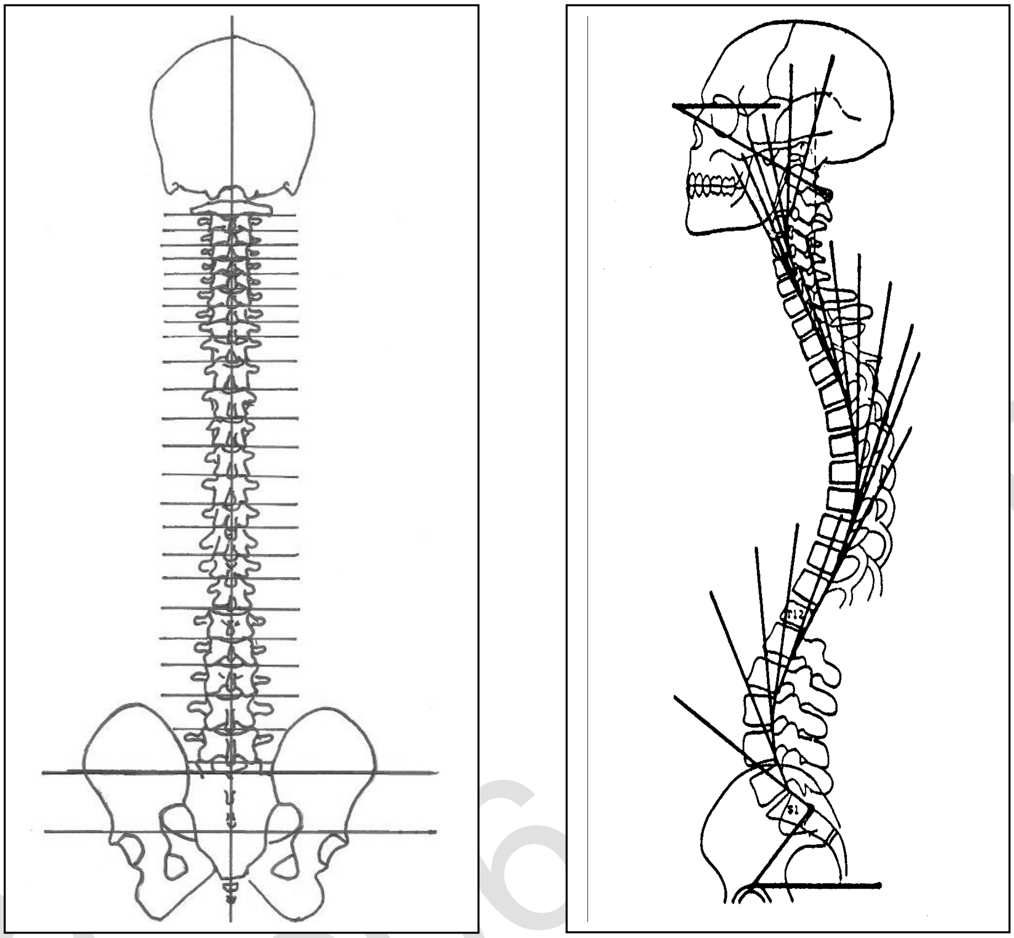

Figure 2AB. In A, the vertical alignment of the entire head, spine, and pelvis is shown. One can either express this alignment as (a) all wedge lines (end plate lines) are parallel, e.g., all Gonstead wedge angles are zero and all Cobb angles are zero, or (b) all centers of mass are vertically aligned, e.g., all Nasium upper and lower angles are zero in displacement from 90º and all Risser-Ferguson angles are zero. The Risser-Ferguson lines will meet the sacral base wedge line at 90º. In B, sagittal alignment is measured as intersecting posterior vertebral body tangents, which create segmental angles at each pair of vertebra (RRAs) or global angles (ARAs) in each spinal region. Regional global angles are formed by choosing a superior vertebra and an inferior vertebra to intersect the posterior tangents, e.g., ARA C2-C7, ARA T3-T10, and/or ARA L1-L5. Reprinted with permission from Harrison CBP Seminars Inc., Evanston, WY.

Since the AP alignment dictates zero degrees displacement in all end plate lines and all lines through centers of mass, it is the average normal sagittal angles (RRAs & ARAs) that are of interest. Below, Tables (1-3) present average normal values for the RRAs and ARAs for the three spinal regions, cervical spine, thoracic spine, and lumbar spine. As expressed previously, these average values are from published average healthy subjects' spinal modeling studies.[6-8]

Table 1. Sagittal Cervical Average[8] and Ideal[9] Normal Values
(Reported as absolute values, since extension is –Rx)

Level	Average Value	Ideal Value
Tz C2-C7 (mm)	4 mm	0mm
Segmental Angles		
C1-Horizontal	29º	29º
C2-C3	6.4º	9.4º
C3-C4	6.9º	8.2º
C4-C5	6.8º	8.2º
C5-C6	6.6º	8.2º
C6-C7	7.8º	8.2º
Global Angles		
ARA C2-C7	34.5º	42.2º
Cobb C2-C7	26.8º	NR
Cobb C1-C7	55.1º	NR

Table 2. Sagittal Thoracic Average[7] and Ideal[10] Normal Values

Level	Average Value	Ideal Value
T2-T3	3.3°	6.8°
T3-T4	5.0°	6.3°
T4-T5	6.5°	5.9°
T5-T6	5.2°	5.5°
T6-T7	6.7°	5.2°
T7-T8	6.2°	5.0°
T8-T9	4.7°	4.8°
T9-T10	3.1°	4.7°
T10-T11	4.4°	4.7°
ARA T3-T10	37.4°	37.4°
ARA T2-T11	45.1°	49.0°

Table 3. Sagittal Lumbar Average[6] and Ideal[15] Normal Values (Reported as absolute values, since extension is –Rx)

Level	Average Value	Ideal Value
T12-L1	0°	0°
L1-L2	2.9°	5.1°
L2-L3	7.4°	6.3°
L3-L4	11.9°	9.1°
L4-L5	16.6°	18.5°
L5-S1	32.4°	33.0°
S1 to horizontal	39.2°	40.0°
ARA L1-L5	39.7°	**40.0° Rounded Up**

Structural Spinal Subluxation Assessment

Despite political attempts to the contrary and continual academic tampering, practicing Chiropractic Clinicians have repeatedly used subluxation and “spinal listings” interchangeably as early as 1910, which is when BJ Palmer took the first chiropractic spinal x-ray in the USA. In other words, the spinal listing is the mechanical description of the subluxation. Historically, spinal listings have been composed of letters of the alphabet to represent the direction in which a vertebra has misaligned, e.g., P = posterior, A = anterior, R = right (spinous movement in PA view), L = left (spinous movement in PA view), S = superior, and I = inferior. These directions of misalignment were observed on spinal radiographs as early as 1910. Without an education in engineering, early Chiropractic Clinicians correctly categorized all the possible movements of a motor unit (listing the top vertebra’s movement relative to the vertebra immediately below) as: axial rotation, lateral bending, flexion-extension, anterolisthesis-retrolisthesis, laterolisthesis, and thin discs. Figure 3 illustrates all twelve possible vertebral misalignments in six degrees of freedom, but with listings expressed in engineering terms as rotations in degrees (Rx, Ry, Rz) and translations in millimeters (Tx, Ty, Tz).[3] The origin or right-handed Cartesian coordinate system is adopted from Panjabi et al in 1974.[23]

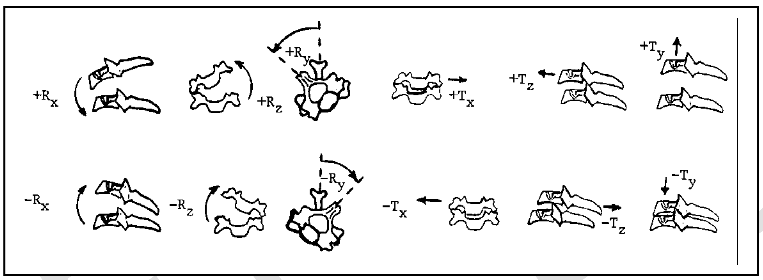

Figure 3. These are the misalignments that early Chiropractors observed on spinal x-rays after 1910. These were later described as rotations and translations in an x-y-z coordinate system in the literature in the 1970s. Using the Panjabi et al.’s coordinate system (Y vertical, X to the left, Z forward), axial rotation is ±Ry, lateral flexion is ±Rz, and flexion-extension is ±Rx, while left and right latero-listheses are ±Tx, vertical translation (thin discs and traction) are ±Ty, and antero- and retro-listheses are ±Tz. Reprinted with permission: Harrison DE et al. Spinal Biomechanics for Clinicians, Vol I., Evanston, WY: Harrison CBP Seminars, 2003

In 1972, the liberal Chiropractic Colleges’ Houston Medicare Conference[13] chose 17 spinal displacements as spinal subluxations to be used by the Federal government in defining spinal subluxation for re-imbursement of services to Chiropractors. These were/are:

A. Static intersegmental subluxations
   1. Flexion malposition
   2. Extension malposition
   3. Lateral flexion malposition
   4. Rotational malposition
   5. Anterolisthesis
   6. Retrolisthesis
   7. Altered interosseous spacing (decrease/increase)
   8. Osseous foraminal encroachment

B. Kinetic intersegmental subluxations
   9. Hypomobility (fixation)
   10. Hypermobility
   11. Aberrant motion.
C. Sectional subluxations
   12. Scoliosis and/or alteration of curves secondary to musculature imbalance
   13. Scoliosis and/or alteration of curves secondary to structural asymmetries
   14. Decompensation of adaptational curvatures
   15. Abnormalities of motion.
D. Paravertebral subluxations
   16. Costovertebral and costotransverse disrelationships
   17. Sacroiliac subluxations

In the above list, it is noted that (1) and (2) are ±Rx, (3) is ±Rz, (4) is ±Ry, (5) and (6) are ±Tz, (7) is ±Ty, (8) happens over time from (1) through (7) and is a pathology not a subluxation, and the Houston Conference members omitted the degree of freedom associated with laterolisthesis, which is ±Tx. Again it is noted that the Houston Conference members added (9)-(11) and (15), abnormal motion, to the list of possible subluxations, which, traditionally in the 8 conservative Chiropractic Colleges, was “bone out of place”. Of course the “Sectional Subluxations” are composed of movements of individual segments in 1 or more of the 6 Degrees of Freedom as a choice of one member (+ or -) from any or all of ±Rx, ±Ry, ±Rz, ±Tx, ±Ty and ±Tz.

It is important to note that using the average normal spinal model in Figure 1 and Tables 1-3, these displacements (listings) can be measured in degrees of rotation and millimeters of translation. Additionally, using the methods suggested in Figure 2A (Gonstead, Cobb, Risser-Ferguson, upper and lower angles on the nasium), it is possible to measure “Sectional Subluxations” (regional subluxations) in degrees of displacement from normal.

However, these “Sectional Subluxations” are more clearly described in engineering terms as buckling, i.e., snap through buckling = sagittal buckling in harmonics or eigenvalues and their eigensolutions (types of “S”-curves), Elastic buckling of a column, or Euler buckling of a column.[44-47]

Since the current guideline document deals solely with vertebral subluxations the extraspinal or “paravertebral subluxations” (#16 and 17 in the above list) will not be discussed.

We have presented the Houston Conference Medicare subluxation definitions[13] for a historical perspective, pointing out that in our present time these displacements can be measured from the average normal spine, and for possible inclusion in a more precise list of subluxation types.

Subluxation Types

Using the reference frame from Panjabi et al,[22] there are four types of observed postural and spinal segmental subluxations (displacements), which have been adequately described in mechanical engineering terms and verified by biomechanical investigations. In 1998, Harrison et al[5] presented a detailed review of the literature of these four types. In the current document, we add to the four types of subluxation discussed by Harrison et al[5] and present these as types of structural/mechanical displacements of the spine (“bone out of place”):

1. Segmental subluxations: These are the segmental displacements from C1-S1 measured from the vertebra above relative to an origin located in the vertebra immediately below. These vertebral spinal subluxations are listed in terms of Rx, Ry, Rz, Tx, Ty, Tz),[43.48-51] (See to Figure 3). Triano[48] discussed these segmental displacements in terms of a buckling phenomenon but only discussed their post-buckled behavior (kinematic alterations) while neglecting the fact that these are associated with static displacements described as their respective post-buckled modes. Furthermore, Triano[48] failed to acknowledge the fact that the only valid way to identify these segmental displacements (post-buckled segmental modes or kinematic alterations) is by radiographic means.[43,49-51]

2. Postural main motion and coupled motion: Postural displacements found in neutral resting stance are completely described as rotations and translation displacements of the head, thoracic cage, and pelvis. The majority of these displacements are concomitantly associated with spinal coupling/displacement patterns.[5,52-56] Each postural displacement has a unique spinal displacement pattern, with which it is normally associated. (**See Figure 4**). When discussing postural rotations and translations as global subluxations, we do not mean dynamic range of motion, but the occurrence of such positions in the neutral resting posture. Of interest, postural displacements from the neutral spine have been modeled as a ‘simple’ elastic buckling phenomenon.[56]

3. Snap-through buckling in the sagittal plane: The alterations in the regional sagittal curves of cervical or lumbar lordosis to kyphosis and “S”-curves and, to some extent, changes in thoracic kyphosis to hypo-or hyper-kyphosis have been found to be consistent with the engineering Snap-through type of buckling.[57-69] According to Nightingale et al[60], referring to Chen and Lui[45], “In a column with a fixed base, buckling is evidenced by an abrupt decrease in measured compressive load with increasing deflection and moment. Snap through buckling is characterized by a visible and rapid transition from one equilibrium configuration to another”.

   Snap through buckling can occur in 1 of 3 ways: a) an abrupt impact load applied to the head, ribcage, or butt, b) an overload event such as bending forward and lifting a very heavy object, or 3) an inertial loading event causing rapid acceleration and inertial loads to the spinal segments such as a rear end motor vehicle accident.[57-69] Increased complexity of the snap-through buckling is delineated in terms of the shape of the curves. An S-shape in any region (cervical, thoracic, lumbar) is the 1^{st} order buckled mode, flexion-extension-flexion in any region is the 2^{nd} order buckled mode, etc… 2^{nd} order and higher buckled modes are caused by dynamic loading and are associated with large increases in potential energy of the system whereas 1^{st} order buckled modes have been produced under static and quasi-static loading experiments. **See Figure 5**.

4. Euler buckling in AP/PA view: This type of structural displacement is generally where the structures of the lower most segments in a spinal region experience some failure, e.g., axial rotation and/or lateral flexion of L4 & L5.[5,70-72] These displacements are generally localized to the distal spinal regions of the cervical, thoraco-lumbar, and lumbo-pelvic and are generally associated with sub-catastrophic (non-complete tears) and sometimes catastrophic (macro) tears in the surrounding ligaments. These occur under similar loading circumstances as Snap through buckling detailed above. **See Figure 6**.

5. Scoliosis: Recently, the pathomechanics and perhaps the eitiology of the non-neurogenic forms of scoliosis have been described by a 'slow-loading' buckling mechanism. [56,73] There are multiple different types, locations and complexities of scoliosis.

6. Static or dynamic segmental instability: These are the segmental displacements depicted in Figure 3 but are at the limit of or outside of the range of motion for the functional spinal unit. These are associated with significant ligamentous trauma. This information is detailed in Section X of this document under dynamic imaging and flexion/extension radiography.[74-82]

These 6 types of subluxation are mechanical descriptions for the allowable spinal displacements that can occur. Using the average normal spinal model, inside normal upright stance, that we precisely defined in Figure 1, these 6 types of displacements can be quantified. It is an important feature that each one of the structural subluxations (except for instability, number 6 above) is a displacement that occurs within the allowable range of motion of the functional spinal motion segment. Thus, these 5 subluxations are static and dynamic mechanical displacements that are sustained within the range of joint motion. Also, we note that the above 6 types of structural subluxation are listed in increasing complexity of the displacement until we reach complete ligamentous failure or instability (number 6).

W*e must emphatically reiterate that all 6 of the above structural subluxations require radiographic analysis for valid identification and quantification.* Surface contour assessments for the sagittal spinal curves are invalid in the cervical region,[83-86] questionable in the lumbar region;[87-90] although some can predict gross thoracic kyphosis.[89,90] However, these methods are not designed to replace initial spinal radiographs, and cannot readily determine segmental alignment.[89,90] Next we compare our definitions of subluxation against Nelson's 6 attributes.

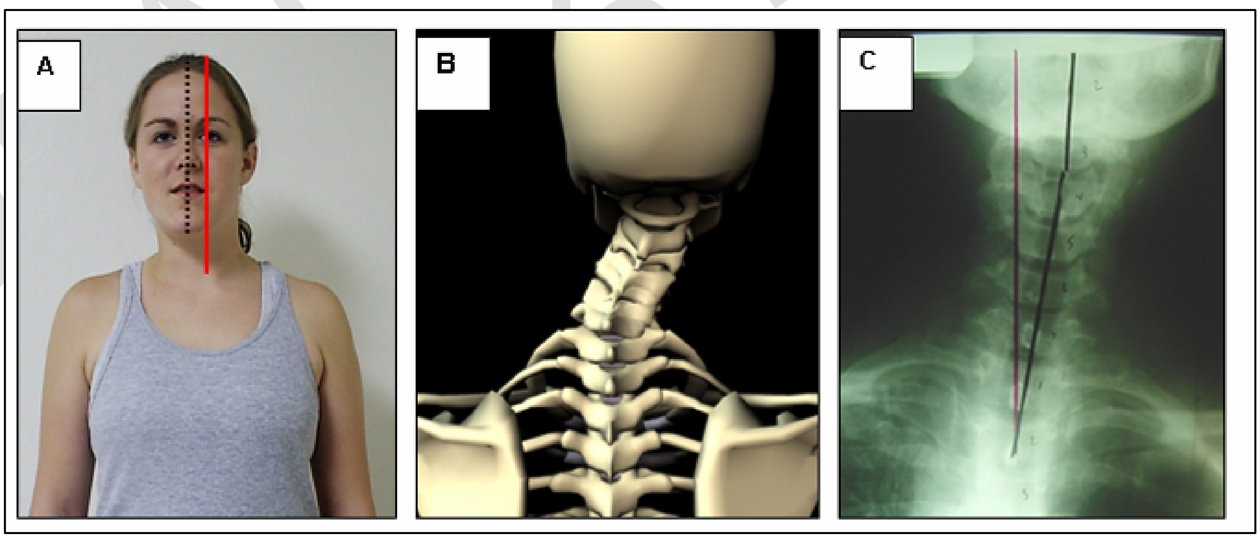

Figure 4. Postural Main Motion and Coupled motion. In A, the posture of right head translation is shown. In B, the skeletal animation from the posterior to anterior view is shown depicting the opposite lateral bending coupling motions in the mid-low cervical spine versus the mid-upper cervical spine. In C, a patient radiograph is shown with the coupling patterns for right head translation. Reprinted with permission from Harrison CBP Seminars Inc., Evanston, WY.

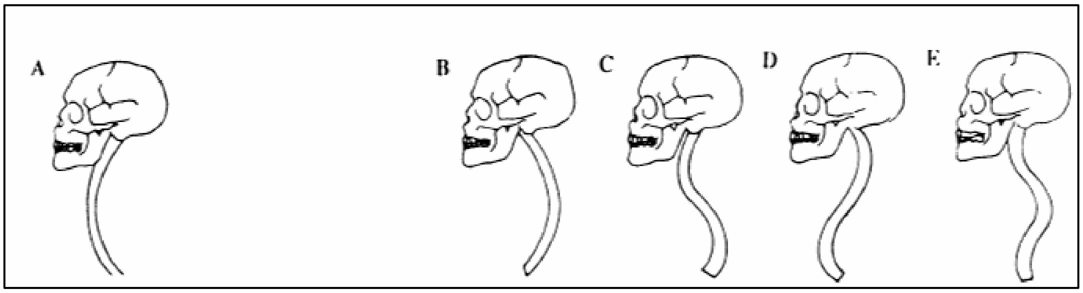

Figure 5. Snap Through Buckling. In A, the neutral lordosis is shown. The buckled modes (B-E) are caused by impact, overload, or inertial loading events. Increasing complexity is referred to as 1st order buckled modes (C and D), 2nd order buckled modes (E), etc…. The allowable shapes can be correlated to eigenvalues in solutions of nonlinear partial differential equations used to model structures.[45,46] Reprinted with permission from Harrison CBP Seminars Inc., Evanston, WY.

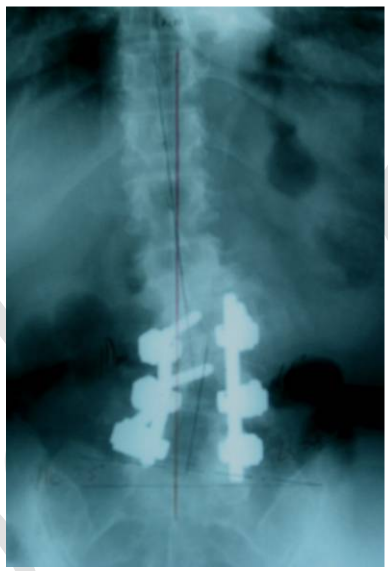

Figure 6. Euler Buckling of the distal lumbar region. A severe case is shown that required surgical stabilization - fixation after a fall from several feet where the patient landed on her bottom. The segments are laterally translated, lateral flexed, axially rotated and flexed (not shown). Reprinted with permission from Harrison CBP Seminars Inc., Evanston, WY.

Subluxation Definitions Compared to Nelson's Attributes

Our 'new' definition of subluxation with its 6 basic types will now be evaluated using Nelson's 6 attributes. The fact that segmental positions (spinal listings) are important in spinal coupling, sagittal buckling, Euler buckling, and segmental instability provides an obvious resemblance to chiropractic's historical antecedents of subluxation. When whole regions are measured as displacements from normal, these segmental displacements are the building blocks that comprise global spinal areas.

This new subluxation definition is testable (Nelson's 2nd attribute) because, using rotations and translations of posture and spinal segments, measurements can be made in 3-D for posture and in 2-D radiographic projections (Section VIII and X provides these measures). The review published in 1998[5] and the current brief review of the scientific literature,[43,48-82] provides the support for Nelson's 3rd item; "It should be consistent with current basic science precepts and principles."

For Nelson's 4th attribute, it is obvious that abnormal postures composed of rotations and translations in 3-D, spinal buckling, and segmental instability, are unique spinal positions. Thus, the correction/reduction of these positions requires specific opposite transformations (rigid body movements caused by chiropractic adjustment forces) in a mechanical engineering analysis.[91] The information, presented herein, does not yet "reflect current practice and educational standards"; but this is not an inherent problem with the definitions of subluxation stated here. However, these concepts are taught in approximately 1/3 of the Chiropractic Colleges in the United States.

For Nelson's 5th attribute, "it should be clinically meaningful", there are many studies on adverse mechanical stresses/strains in the CNS,[92-94] many studies on the adverse loads (stresses/strains) on the spinal tissues,[67-69] and many studies on the adverse loads on mechanoreceptors for displacements from the average normal spine depicted in Figure 1. Davis' Law (soft tissue remodels to stress) and Wolff's Law (bone remodels to stress) provide enough "clinically meaningfulness". This area of "clinically meaningful", adverse health consequences and studies which show that deviations from the ideal are associated with pain or other disorders will be expanded upon in Section X and under each specific radiographic view and in Section XII on joint mechanoreceptors and pain.

For Nelson's 6th attribute, "it should present a distinct and unique point of view", these 6 types of subluxation, are unique rigid body movements, taught as possibilities in Linear Algebra (rotations and translations) and as different types of buckling in mechanical engineering.[44-47,91] It provides the basis for chiropractic to remain a unique healthcare field. Nevertheless, segmental correction, posture correction, and correction of the sagittal spinal curves have been associated with a multitude of health benefits in the literature to date. Evidence for this statement will be provided in a later section of this document (see Section X).

Anatomic/Anomaly Variants Affecting Spinal Geometry

An important topic when discussing our average spinal models' application to the human population is a consideration of anatomical variations in a given persons spinal anatomy. There are several known anatomical variants of human spinal anatomy that affect spinal alignment/geometry, however, there are several variants that do not. Significant progress has been made in understanding the correlations between a variety of anatomical variants and spine geometric alterations; Chiropractic clinicians and researchers have played a significant role in this area of investigation.

Problematically, this area of investigation has given a subgroup of publishing Chiropractic Radiologists (DACBR's) and academics an avenue for open ended criticism and cause to berate and chastise chiropractic techniques and clinicians who are interested in structural spinal rehabilitative patient treatment and outcomes.[37,95-99] In fact, instead of looking at the evidence for and against specific anomalies and spinal geometric alterations, these individuals have fabricated cause and effect relationships, based their criticisms on flawed investigations, and have relied mainly on Class V (expert opinion) evidence without acknowledging the progress innovative chiropractic pioneers and clinicians have made in accommodating the variants.[37,95-99]

For example, in a recent 2005 Chiropractic text, Peterson and Hsu,[37] claim that chiropractic roentgenometric measurement of spinal subluxation is "…*controversial within the profession, particularly because the impact of natural and normal asymmetries with the body on these measurements is not known.*" In support of their[37] statement, the opinion article by Haas et al[95] and the investigation by Peterson et al[96] are offered. Concerning the Haas et al[95] opinion article, a claim was made that 'natural asymmetry' of the spinous processes would in fact alter spinal geometry in the AP view. However, no evidence was provided for their statement of cause and effect. In contrast, over two decades ago, Farfan[100] found that when the spinous process is asymmetrical, the entire vertebral architecture will change and keep the lamina junction in line with the structural center of the vertebral body. This means the center of mass of the vertebral body will remain approximately the same. Farfan[100] states "*It would appear that in the development of the vertebra, asymmetrical body growth is compensated for by asymmetric growth of the neural arch*". In 2000, Harrison et al[38] pointed out the erroneous statement by Haas et al. This panel questions why Peterson and Hsu[37] continue to ignore this?

The second investigation offered by Peterson and Hsu[37] to criticize the chiropractic clinicians' use of spinal radiography, is the study by Peterson et al.[96] With a small sample size and no segmental analysis of cervical lordosis, Petersen et al[96] claimed that alterations in the angle of the facet surfaces in the sagittal plane caused a reduction in the magnitude of the cervical lordosis. The origin of claiming that facet architecture/angles influence the cervical curve can be traced to a 1977 self-published text by MacRae.[97] In this 1977 text, only Class V evidence is given for MacRae's[97] hypothesis. In a letter to an editor, Winterstein[98] claimed that "short pedicles and vertically facing articular facets predispose to a cervical hypolordosis or kyphosis." Winterstein[98] offered no references for such statement but presumably was referring to MacRae (1977).[97] In line with previous claims, the results from Peterson et al[96] were challenged in a letter by Harrison et al[101] for several reasons but these criticisms still go ignored. More importantly, Harrison et al[102] performed a much needed investigation using 252 subjects, where the correlation between articular pillar height, facet surface sagittal plane angles, and the shape of the dens and the segmental and total cervical spine curvature was determined. Harrison et al[102] state,

> *"In contrast to chiropractic radiology paradigms in the literature, we found no statistical correlation with hyperplasia of the cervical facets (superior and inferior facet surfaces that diverge to the posterior) and any segmental or global angle of cervical lordosis. Additionally, there is no correlation with the vertical heights of the cervical facets and any segmental or global angle of cervical lordosis."*[102]

In light of the above, the current Practicing Chiropractic Panel of experts hopes that intellectual honesty and professional duty will create a shift in these happenings. As stated previously, there are spinal anatomical variants that do affect the geometry of the spine. These include the following:

1. Sagittal plane wedge angles of the vertebral bodies,[103-105]
2. Coronal plane wedge angles of the vertebral bodies (hemi-vertebra),[114]
3. Anomalies of the skull condyles,[99,106-110]
4. Transitional vertebra at L5-S1,[111,112]

5. Congenital and surgical blocked vertebra,[113] and
6. Pelvic/sacral morphology.[39-42]

Chiropractic pioneers (clinicians and researchers) and other health care physicians are on the forefront of investigating spinal anomolies, learning to identify them via radiographic means, and developing treatment strategies that account for the anatomical variances.[105-108,111]

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