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Critical Review

Selective Usage of Medical Practice Data, Misrepresentations, and Omission of Conflicting Data to Support the 'red flag only' Agenda for Chiropractic Radiography Guidelines: A Critical Review of the Jenkins et al. article: "Current evidence for spinal X-ray use in the chiropractic profession."

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Abstract

A recent paper by Hazel Jenkins and colleagues attempts to present 'Current evidence for spinal X-ray use in the chiropractic profession.' Unfortunately, the review represents an author opinion, 'red flag only' guideline consistent with the practice of medicine, not chiropractic.

In detail, we critically analyze the inappropriate and extensive use of selected medical references (i.e. for the practice of general medicine), the neglect of essential and important evidence that must be considered for a full and balanced discussion of chiropractic X-ray use, and erroneous statements in contradiction with the expansive understanding of spinopelvic biomechanical parameters that has occurred over the past 15 years and the fact that these critical parameters must be assessed by routine full-spine radiography.

The concept that spine and postural displacements of a patient impacts their health and wellbeing is a well framed evidence-based practice in the spine literature. Specific, contemporary chiropractic approaches, like contemporary spinal surgery techniques, can improve postural faults and restore normal function and wellbeing.

In the end, the conclusions made by Jenkins et al. are recycled medical practice imaging guidelines for 'red flags' only, are representative of a one-sided debate, and are not an accurate assessment of X-ray use for the practice of evidence-based contemporary chiropractic spine care.

To be valid, future chiropractic guidelines must include a consideration of the assessment of the critical spinopelvic parameters and the use of contemporary chiropractic methods used to correct these spinal subluxation deformities as detailed in this critique.

Key words: *X-ray guidelines, evidence-based practice, chiropractic, spinopelvic parameters, subluxation*

Introduction

The recent 'narrative review' by Jenkins et al. published in the journal *Chiropractic and Manual Therapies* was purported to present current evidence for spinal X-ray use specifically for the *chiropractic* profession.¹ After a detailed review of this article, we note several serious flaws; where the tone is deceptively commanding as if it were a systematic literature

review with 'meta-analysis'. In fact, the Jenkins et al. manuscript is a 'narrative review' with data interpretations, left fatally in the hands of the authors themselves.²

Still, on the surface, it appears to be a nicely laid out article addressing important considerations for spinal imaging by x-

ray, however, a knowledgeable reader will quickly notice the extensive use of selected medical references (i.e. for the practice of general medicine), the neglect of essential and important evidence that must be considered for a full and balanced discussion of chiropractic X-ray use, and erroneous statements. In the end, the conclusions made by Jenkins et al. are recycled medical practice imaging guidelines for 'red flags' only, are representative of a one-sided debate, and are not an accurate assessment of X-ray use for the practice of evidence-based contemporary chiropractic spine care.

Herein, we provide a detailed critique of the Jenkins et al.¹ review and point out critical flaws, while offering a more balanced discussion for the chiropractic profession whose interest still lies in understanding/improving the relationship between spinal alignment and human health disorders. We use the format provided by Jenkins et al.,¹ thus, mirroring the articles originally laid out sections for ease of critical assessment for interested readers.

Sections 1 and 2: Current use and evidence for obtaining spinal X-rays within chiropractic practice

Jenkins et al. state that reasons given for X-rays by chiropractors are varied with "many not supported by evidence."¹ They list the following 6 reasons. Next, we discuss the omitted evidence for each in the Jenkins et al.¹ review and offer an alternative viewpoint:

- A. Diagnosis of pathology or trauma
- B. Determination of treatment options
- C. Screening patients for contraindications prior to care
- D. Spinal biomechanical analysis
- E. Patient reassurance
- F. Medicolegal reasons

A. Diagnosis of Pathology or Trauma

The use of x-ray imaging for traditional 'red flags' (malignancy, fracture, ligament instability, etc.) is an obvious evidence-based practice. In fact, as part of our educational requirements, all chiropractors learn spinal imaging necessary for the proper assessment of possible traumas and pathologies, so-called 'red flags.' Thus, we will not discuss these as they are thoroughly covered in chiropractic college curricula, are covered in existing spine imaging guidelines and radiology text books since these conditions usually warrant timely medical (not chiropractic) treatment.

It is noted, however, that Jenkins et al.¹ state that the routine use of X-rays is not recommended due to the rarity of 'red flag' pathologies identified on X-ray, citing studies showing ranges of 0.2-3.3% for 'serious pathology' and 0.2-6.6% for 'fracture.'²⁻⁶ In our opinion, the incidence rates of 3.3% or 6.6% are not rare in a busy chiropractic clinic. These rates translate to 1/30 for a serious pathology, and 1/15 for a fracture. A typical established chiropractic clinic may easily see 5-10 new patients a week that equates to 240-480 new patients in a year.

This means the probability of diagnosing (if X-rays are taken) or misdiagnosing (if Jenkins et al.'s¹ recommendations are strictly followed) 16 to 32 fractures, and 8-16 serious

pathologies requiring medical/emergency referral in a single year. These estimates are not insignificant considering multi-year time frames. Just one of these encounters not diagnosed (by X-ray) and inappropriately treated by chiropractic may lead to serious injury or harm to the patient either directly, or indirectly by delaying more urgent needed medical (non-chiropractic) treatment; both scenarios render the chiropractor liable.

Further, of the 5 citations showing low incidence rates of trauma and serious pathology listed by Jenkins,²⁻⁶ only one was from a chiropractic clinic, all else were from medical practice studies. It is assumed that the incidence of patients presenting to chiropractors with these conditions disguised as back pain are similar, but this has not been verified. In fact, the Beck chiropractic study⁴ demonstrated the high ends of the incidence rates for both malignancy (3.1%) and fracture (6.6%).

B. Determination of Treatment Options

Radiological screening to determine treatment options, for a significant portion of the chiropractic profession, is a routine and evidence-based practice.⁸ Jenkins et al.¹ and other 'red-flag only' chiropractic X-ray guideline advocates (i.e. Bussierres et al.⁹) neglect / reject the validity of biomechanical analysis as an important treatment consideration.

The current authors acknowledge that for pain-based or symptom-relief chiropractic treatment, those providers who practice a general type of 'gross spinal manipulation,' perhaps routine imaging is not as an important consideration. However, it is essential that any contemporary radiographic guideline for the chiropractic profession recognize that for many currently practiced and evidence-based techniques radiographs are critical and definitively guide treatment procedures.

Examples of these techniques in the peer-reviewed literature include: Chiropractic BioPhysics® (CBP®) techniques,¹⁰⁻²⁵ Pettibon techniques,²⁶⁻³¹ upper cervical techniques,³²⁻³⁴ and scoliosis-specific programs.^{27-31,35-38} To be valid, any current chiropractic X-ray guideline must account for these practices; to our knowledge there are some chiropractic guidelines that do.³⁹⁻⁴²

Forward head posture (FHP), for example, is a very common postural disorder that is amenable to corrective treatments. As has been pointed out by Harrison et al.,⁴³ and the randomized trials by Moustafa et al.^{14-16,18,19}, the correction of a patient's forward head posture needs to be customized according to the radiographic alignment apparent on the lateral cervical view that demonstrates the internal shape of the cervical spine.

A hyperlordotic versus a kyphotic cervical spine in a patient having FHP, based on current evidence-based methods, requires differentiation as the treatment approaches will differ; this differentiation can only be accomplished by X-ray analysis.^{14-16,18,19,43,44} The same is true for many other spine displacement patterns (thoracic hyperkyphosis vs. thoracic hypokyphosis, true scoliosis vs. pseudo-scoliosis, lateral thorax and head translations, posterior thoracic sagittal balance vs. anterior thoracic sagittal balance, etc., etc., etc.).

As discussed by Oakley et al., it is obvious that modern, evidence-based practice requires routine x-rays as they are essential in the accurate diagnosis of the biomechanical relationships that dictate and guide patient-specific treatment approaches.⁴⁴ More discussion of radiographic spinal screening of spinopelvic and cervico-thoracic biomechanical parameters will be discussed later.

Jenkins et al.¹ state: “*we could find no studies assessing the impact of routine imaging on technique modality selection resulting in improved patient outcomes... there is a lack of high-quality evidence to indicate which technique modalities are superior for a given condition. Furthermore, spinal X-ray has not been found to be a useful method to determine the site of spinal manipulation.*”

Based on the brief prior discussion, these statements are interpretive opinions, contradicted by existing data related to X-ray use for chiropractic methods. Interestingly, data from a recent debate, indicates that Jenkins et al.¹ rather purposefully chose to ignore findings reported in high-quality randomized trials that definitively demonstrate that X-ray image-guided treatments *do* lead to improved patient outcomes.^{45,46} It is interesting that Jenkins et al.¹ had referenced 3 RCTs that demonstrate the superiority of X-ray-guided treatment results by the Moustafa group (Jenkins et al.’s¹ references 75-77) but then they¹ failed to realize the data trend represented in these trials.

This raises the issue of blindly treating a patient like a ‘black box’. Many therapists have cookie-cutter approaches for common spinal disorders including gross manipulation, stabilization exercises, heat, ice, muscle stimulation, inversion table, etc. There is a sufficient quantity of good quality studies that clearly demonstrates that patient-specific treatments using evidence-based contemporary approaches to common spinal disorders of cervical hypolordosis, lumbar hypolordosis, upper cervical subluxation and scoliosis lead to superior outcomes versus conventional care; these evidence-based approaches are guided exclusively from x-ray screening⁸⁻³⁶ as other analysis methods are either ineffective at quantifying spine alignment (photography, thermography, etc.) or not practical in daily practice (i.e. standing MRI).⁴⁴

A final comment here is that the fundamental teachings of chiropractic vertebral adjusting techniques involves the introduction of manual forces which require precise vectors to be adopted for optimal delivery of the thrust forces that are applied to particular spinal facet joints. A very important notion is that not all chiropractors use ‘gross manipulation’ as is used in general physiotherapy and for which much of the manual therapy for LBP literature pertains.⁴¹

Cervical segmental adjustments will have different optimal thrust force vectors depending if the patient has a physiologic lordosis versus a pathologic kyphosis, for example. The same goes for other levels of the spine where the ‘segmental adjuster’ matches appropriate vectors of thrust to the various joints of the body while simultaneously considering the patients’ actual spinal position. This is the precision of the teaching methods that the current authors received during their attendance in chiropractic college.⁴¹

C. Detection of Contraindications to Care

In this section Jenkins et al.¹ briefly discuss screening for unsuspected serious pathology (i.e. traditional ‘red flags’) that, in many scenarios, indicates MRI as first imaging over X-ray. This is justified for serious pathology which would necessitate medical and not chiropractic management.

Jenkins et al.¹ only present a brief discussion of *upper* cervical anomalies, where it is argued that contraindications for ‘manipulative therapy’ is only based on a “*theoretical basis, rather than documented clinical evidence of harm*” citing the 1991 Gatterman paper.⁴⁷ Further, citing a recent paper by Swait and Finch,⁴⁸ Jenkins et al.¹ state that this paper did *not* report any harm from manipulative therapy to the spine in the presence of upper cervical anatomical anomalies. In contrast to Jenkins et al.¹ interpretation, however, the Swait study concluded:

“*Existing literature indicates that benign adverse events following manual treatments to the spine are common, while serious adverse events are rare.*”⁴⁸ Benign adverse events, although not catastrophic, are important to the patient, and present challenges in daily practice. Swait and Finch also state: “*Since serious adverse events could result from pre-existing pathologies, assessment for signs or symptoms of these is important.*”⁴⁸

This suggests clinicians should practice with due diligence, and should complete thorough and comprehensive examination prior to care; the only way to rule out ‘pre-existing pathologies’ is by a thorough spinal exam including an initial set of spinal X-rays.

Jenkins et al.¹ concludes the section by stating: “*The low prevalence, combined with uncertain clinical significance suggests that the use of routine X-ray to screen for congenital anomalies in asymptomatic patients is not supported by evidence.*” Problematically, most patients seeking chiropractic care are indeed symptomatic, *not* asymptomatic.⁴⁹⁻⁵¹ This is important as symptomatic patients are a different population requiring an ethical and comprehensive examination and treatment plan.

Specifically considering the role of chiropractic treatment interventions, there have been several studies, ironically one by Jenkins, that have indicated that spinal radiograph screening confirms a *high percentage of patients have significant abnormalities affecting treatment.*^{4,39,52-55} We find it very concerning that, Jenkins et al.¹ state that anomalies of the ‘upper’ cervical spine have a prevalence between 2.1-3.7% - (they¹ reference Beck (2004)⁴ and herself (2010)⁵²).

However, in the 2010 Jenkins et al. paper,⁵² she and her colleagues actually determined that 28.5% of 2814 screened cervical X-rays demonstrated anatomical anomalies, and regarding the lumbar spine, Jenkins et al.⁵² determined that 18.2% of 1052 screened lumbar X-rays showed anatomic anomalies. It is surprising, Jenkins et al.¹ only refer to the ‘upper’ cervical spine, when clearly, they¹ are aware of a much *higher* rate of spine anomalies diagnosed by routine radiography as proven by Jenkins and others.^{4,52-55}

Spinal anomalies, pathologies and contraindications to manual spinal manipulative therapy are actually very common in clinical practice,^{4,52-55} for example, as determined from spinal x-rays or their reports studies have identified that:

- 94% of 262 patients had postural changes (Young⁵³),
- 91% of 413 patients had anomalies/pathologies (Pryor⁵⁴),
- 68% of 847 patients had anomalies/pathologies (Beck⁴),
- 44% of 262 patients had serious pathology (Young⁵³),
- 33% of 1698 patients had relative contraindications to manipulation (Bull⁵⁵),
- 28.5% of 2814 cervical radiology reports indicated congenital anomalies (Jenkins⁵²),
- 18.3% of 1052 lumbar radiology reports indicated congenital anomalies (Jenkins⁵²),
- 14% of 1698 patients had absolute contraindications to manipulation (Bull⁵⁵),
- 6% of 847 patients had absolute contraindications to manipulation (Beck⁴).

Information regarding anomalies and pathologies are especially important for chiropractic clinicians performing structural corrective types of techniques (discussed above) aimed at altering the spine and posture. This mandates an initial radiographic examination be performed. As stated by Maigne et al.⁵⁶ and reiterated by Kent,⁴² structural based manual interventions are modified when anomalies and pathologies are present in a specific patient's spine.

D. Spinal Biomechanical Analysis

Spinal biomechanical analysis of a patient provides important information regarding both causation and treatment strategies for their ailments,⁸⁻³⁶ but ironically this information gets either ignored and/or down-played by anti-imaging chiropractic advocates who state spine alignment and posture does not matter and has no correlation with symptoms or health.^{1,9} Jenkins et al.¹ cite two studies in support of arguing that spine alignment does not relate to health outcomes.

The first is the 2003 Murrie et al.⁵⁷ article that used MRI analysis of lumbar lordosis in patients lying supine; previously, we had pointed this and other significant criticisms of the Murrie et al.⁵⁷ investigation out in a letter-to-the-editor 16 years ago.⁵⁸ The second supporting reference by Jenkins et al.¹ is the Chapman⁵⁹ 2016 paper that pertained to lumbar scoliosis patients, however, this study demonstrated statistically significant relationships between radiographic spinopelvic parameters and patient-reported outcomes and does not support Jenkins et al.'s¹ argument.

Tragically, those who hold the viewpoint of believing there is no relation between spine alignment and health outcomes typically cite the systematic review (SR) by Christiansen and Hartvigsen⁶⁰ as Jenkins does, by stating that any study findings showing symptomatology associated with spinal curves "must be balanced by" the Christiansen/Hartvigsen paper.⁶⁰ Importantly, the SR by Christiansen and Hartvigsen⁶⁰ on sagittal curves and health has been heavily criticized by Harrison et al.⁶¹ and others.⁴⁶

At over a decade old, this SR⁶⁰ was proven to be critically flawed.^{46,61} Christiansen and Hartvigsen⁶⁰ omitted dozens of relevant investigations that should have been included, and they misinterpreted study findings; in fact, to detail how poor this review was, an entire paper was written describing its shortcomings.⁶¹ This detailed re-analysis revealed that 74 papers were omitted, where the conclusions of the re-analysis indicated that "*the majority of studies (100/128 or 78%) have found a positive association between sagittal plane curves/posture and health disorders.*"⁶¹

Furthermore, within the last decade (2010-2019), dozens of high-quality, more recent studies, have affirmed the association between posture, spinal curves, sagittal balance and diverse health outcomes including pain, function, disability and health-related quality of life.⁶²⁻⁷⁶ Inexplicably, these recent investigations were completely ignored by Jenkins et al.¹ in favor of the flawed and dated Christensen and Hartvigsen⁶⁰ SR.

While acknowledging that X-ray line drawing has good inter- and intra-examiner reliability, Jenkins et al.¹ state: "*the clinical relevance of these findings and usefulness in directing subsequent treatment selection has not been sufficiently demonstrated,*" and concluded this section by stating: "*there is currently insufficient evidence to recommend the use of routine spinal X-rays to analyze spinal biomechanics.*"

In contrast to their¹ viewpoint, we submit the biomedical literature detailing posture, spinal curves, sagittal balance, and the relationships between various spinopelvic parameters is replete with relevant data that documents the need for routine spine imaging in patient populations. Specifically, in the last decade the term adult spinal deformity (ASD),^{77,78} has been popularized in the surgical and spine radiographic literature; of which ASD essentially categorizes different types of spinal subluxation patterns.⁷⁹ In the spine literature, ASD specifically refers to the following spine deformity (subluxation) types as assessed with radiographic methods and present in any person 18 years and older (Figure 1 depicts these types):^{77,78,80-82}

1. Thoracic hyper-kyphosis with a magnitude greater than 60°;
2. Anterior (positive) sagittal balance of the C7-S1 plumb-line greater than 5cm;
3. Any frontal view scoliosis of greater than 20°;
4. Sagittal pelvic tilt angle (PTA) greater than 25°. Note, due to the inverse relationship between this PTA measurement and sagittal sacral tilt angle, it is actually descriptive of a sacral base angle (SBA) being decreased where normal SBA = 40, and normal PTA is approximately 17-18°. Thus, this measurement clearly describes lumbar hypo-lordosis in the distal lumbar region (See Figure 1).

Sadly, anti-imaging proponents within chiropractic (including Jenkins et al.¹) fail to grasp the fact that poor posture and spinal misalignment, so-called ASD, is an epidemic with devastating health effects.^{80,81,83-93} In fact, both the European Spine Study Group (ESSG)⁸⁰ and the International Spine Study Group (ISSG)⁸¹ have determined that patients with ASD have profound health problems resulting from their spine

displacement deformities (i.e. subluxation types⁷⁹).

For example, Pellise et al. (ESSG)⁸⁰ found that patients with ASD over the age of 18, had significantly poorer SF-36 health-related quality of life scores than patients suffering from the common conditions of self-reported arthritis, chronic lung disease, diabetes, and congestive heart failure. They concluded: *“The global burden of ASD was huge compared with other self-reported chronic conditions in the general population of eight industrialized nations. The impact of ASD on HRQOL warrants the same research and health policy attention as other important chronic diseases.”*⁸⁰

The spine literature has provided a substantial evidence-base for X-ray-guided spine alignment surgical considerations and guidelines to achieve successful long-term, post-surgical outcomes for various forms of ASD.⁶²⁻⁷⁶ The full biomechanical assessment of a patient must include an evaluation of gait, posture and a close scrutiny of spine alignment from standing radiographs. In fact, it is widely accepted that an *“accurate assessment of ASD requires a thorough radiographic evaluation of both the spine and pelvis, including concomitant assessment of the cervical, thoracic, and lumbar spine, as well as the femoral heads and pelvis.”*⁸² There is no replacement for standing radiographs in order to assess spinopelvic parameters;^{44,94} these must be taken routinely by those who assess and treat patients for their corresponding ASD subluxation patterns, whether surgeons or chiropractors.

The biomechanical literature on spine alignment and the interrelationships between key spinopelvic parameters are so well understood that there are critical biomechanical postural parameter thresholds used as ‘goals of care’ in spine surgery that are associated with improved patient outcomes.^{67-70,82-88} Spinopelvic parameters critical to superior patient outcomes include:

- Ensuring the maintenance/establishment of a normal range of lordosis in the cervical (CL) and lumbar (LL) spinal areas,
- Ensuring a properly balanced and magnitude of kyphosis in the thoracic spine (TK),
- Achieving a threshold for the minimization of forward sagittal thoracolumbar balance (SVA),
- Minimization of sagittal cervical spine balance (cSVA),
- Optimizing the pelvic parameters of sacral slope and pelvic tilt,
- Ensuring verticality in the coronal plane as measured from standing patient radiographs.

Further, there are patient specific spinopelvic measurements that are critically important as they represent individual-specific morphological parameters that dictate a customization of spine alignment to the particular patient including the pelvic morphology⁸⁹ and the thoracic inlet angle.⁹⁰ These and other important spine interrelationships between specific parameters such as the pelvic incidence minus lumbar lordosis (PI-LL)⁷³ and the slope of C7 or T1 minus cervical lordosis (CS-CL, TS-CL)^{91,92} have led to important patient-specific parameters in the quest for superior X-ray-guided treatment outcomes.

Current research is exploring specific theoretical and empirical equations to understand spinopelvic relationships to aid in treatment, such as described in the recent paper by the ISSG on how the CL and T1 slope affect the cSVA.⁹³ Importantly, all these spinopelvic parameters have ideal averages, ranges, and/or thresholds that are used as standards for goals of care in both surgical^{62-75,77,78,80-93}, rehabilitation^{10-19,76}, and chiropractic^{20-25,38,41,44,79} literature. It is utterly shocking to us that Jenkins et al.¹ would have the chiropractic profession believe this voluminous information doesn't exist.

Jenkins et al.¹ also suggest *“alterations in X-ray spinal alignment may also reflect other factors such as variations in patient positioning during X-ray imaging, pain, or short-term muscle spasm, and as such may not be appropriate to inform ongoing patient management.”* In contrast to this assertion, the repeatability of patient positioning has been thoroughly studied; it has been determined to be highly repeatable, minutes, hours, days, months and even years apart.⁹⁵⁻¹⁰¹ In fact, it was demonstrated in the 1970s that radiographs are highly repeatable as Beck and Killus¹⁰¹ stated: *“several x-rays of the same individuals furnished reproducible results, even though they were taken years apart.”* Furthermore, the recent RCT's by Moustafa and colleagues,¹⁰⁻¹⁹ and non-randomized trials by Harrison et al.,²⁰⁻²⁵ conclusively prove that radiographic positioning is highly repeatable in as much the comparison groups receiving either no care, or standard care but no corrective interventions, were found to have identical spine alignment measures on repeat radiographs taken, weeks, months, and years apart.

Likewise, pain as a reason for variation is valid if it is an acute antalgic patient, for which an attending doctor would be fully aware and accordingly would not rely on the imaging as representative of a definitive baseline posture. ‘Short-term muscle spasms’ as a source of variation are again only valid for an acute antalgic patient, however, most patients presenting for treatment for spine pain have been suffering for some time and will not have their spine alignment affected by muscle spasms.

Even if a patient did have a cervical muscle spasm, it has been shown that most often cervical muscle spasms would result in an increase in lordosis, not a decrease.¹⁰² Thus, the sources of possible variation accounting for changes in spine alignment as suggested by Jenkins et al.¹ are of little concern in the majority of clinical scenarios and these have been extensively discussed in the chiropractic literature previously; which, curiously Jenkins et al.¹ have ignored.^{39,41,95,96}

Ironically, as stated earlier, Jenkins et al.¹ does acknowledge that *“treatment directed by biomechanical X-ray analysis of the spine has shown some evidence for a positive effect on both spinal curves and pain”* and cites 2 RCTs by Moustafa and colleagues.^{12,17} Obviously, and as illustrated (Figures 2 and 3) Jenkins et al.¹ have missed many other RCTs showing definitive positive treatment effects corresponding to X-ray-guided spine / posture improvements.¹⁰⁻²⁵

One of these cited papers¹⁷ reports on improvements of flexion-extension kinematics in the cervical spine – this is characteristic of an entire change in biomechanical function and physiology resulting from the correction in cervical

lordosis and well beyond simple pain relief. This article, as stated clearly in the manuscript is also the sister article to data presented previously¹⁰ documenting improved electrophysiological parameters of nerve root function, again, not mentioned by Jenkins et al.¹ The other Moustafa trial cited¹² demonstrated not only pain improvements, but statistically significant improvements in lumbar lordosis, Oswestry disability index, back and leg pain, modified Schober test, latency and amplitude of H-reflex, and flexion-extension kinematics favouring the treatment group after 6-months follow-up after receiving X-ray guided treatment.

Jenkins et al.¹ also state that of the 'some evidence' showing associations between spine alignment and pain, "findings related to pain are not consistently demonstrated" citing the trial by Diab in JMPT (2013).¹¹ Importantly, this trial clearly demonstrates superior results for pain reduction at the 3-month follow-up, where Diab et al.⁹ state: "*The posttest revealed stable results at follow-up for the study group ... in contrast, there were significant changes in the follow-up scores for comparison group toward the initial baseline.*"

We are not sure how Jenkins and colleagues¹ could misinterpret this statement, which clearly describes the X-ray-guided group had maintenance of improved pain levels at follow-up; the non-X-ray-guided treatment group had a regression of pain levels towards pre-treatment values. In the current authors' opinion, this obvious misinterpretation of high-quality RCT evidence by Jenkins et al.¹ displays gross negligence as paralleled in the Christiansen and Hartvigsen paper.⁶⁰

The Jenkins et al.¹ radiographic guideline for 'chiropractors' has completely missed an extensive body of evidence (for example, several dozens of papers cited herein) and is boiled down to just another "narrative opinion" of adapted allopathic medical guidelines for chiropractic. The fact is, within chiropractic and manual medicine, there are many high-quality RCTs documenting that X-ray-guided spine treatment definitively leads to superior patient outcomes versus standard or conventional care (See Figures 1 and 2).

There is high-quality evidence showing that radiographic determined rehabilitation strategies to improve anterior head carriage, cervical lordosis, lumbar lordosis, scoliosis, and thoracic hyperkyphosis by chiropractic and other manual therapy approaches, does indeed yield statistically improved patient outcomes. None of this evidence is presented by Jenkins et al.¹ Any valid guideline for chiropractors needs to include a consideration of contemporary, evidence-based structural rehabilitation methods as are currently practiced, and in a constructive way, guide clinicians in performing essential routine X-ray analyses to biomechanically evaluate spine deformities/subluxation patterns while maintaining ethical and evidence-based principles of practice.

E. Patient Reassurance

Ironically, the argument that X-rays should not be taken to appease the patient may be one of the greatest reasons to perform imaging. Unfortunately, in the highly competitive healthcare market, the only thing that actually matters is whether or not a provider can successfully satisfy the patient.

An unsatisfied patient will go elsewhere to seek out a more favourable outcome (including imaging). The problem here is that suffering patients have often seen multiple healthcare providers, and it is common that the chiropractor becomes that 'last hope' prior to giving in to more invasive procedures, often surgery – which has the possibility of serious risks and unfavourable outcomes.¹⁰³⁻¹⁰⁵

It is often argued, as Jenkins et al. do,^{1,45} that radiographic imaging of the low back leads to no difference or even poorer patient outcomes. The classic medical study cited for this argument is the Kendrick study.^{106,107} Jenkins et al.¹ along with Kawchuk et al.⁴⁵ used this reference for this very argument recently. It was pointed out by Oakley, Cuttler and Harrison,⁴⁶ that ironically, patients in the Kendrick^{106,107} study who received radiography were in fact more satisfied with the care they received. Further, it was also determined that patients allocated to a preference group (where the decision to receive lumbar radiography was made by them) achieved clinically significant improved outcomes as compared to those not able to choose (randomized without choice to a non-radiography or a radiography group).^{106,107}

Even though this is an inappropriately used MD paper for a chiropractic argument, this finding suggests regardless of essential biomechanical parameters necessary for modern chiropractic treatment consideration, patients who expect and want X-rays should receive them to ensure better clinical outcomes. In our view, after more than 35 years of combined clinical practice, there is nothing more reassuring to a patient (and chiropractor) than being given a proper diagnosis (including conditions ruled out) particularly when the patient has seen other providers (MDs and DCs) who neglected to perform initial imaging; as goes the old adage, 'X-rays don't lie.'

F. Medicolegal Reasons

In all practicality, this reason alone is sufficient to warrant routine radiography considering: it completes a thorough examination, it confirms a diagnosis/non-diagnosis (without guessing), it satisfies the patient (as discussed above), it satisfies the doctor (potential liability), and it has been established to be completely harmless (many times less radiation than the threshold for cancer induction).^{44,94,108,109}

Despite all of the listed reasons having supporting evidence, Jenkins et al.¹ suggests it is due to lack of education, owning an X-ray machine or being subscribed to a particular technique that chiropractors routinely take X-rays. Although these are possibilities and conjecture, we suggest that subscribing to a particular technique is an obvious reality for practicing chiropractors. Using a specific technique procedure or technique in general is an example of evidence-based practice in as much as technique training, is a mandatory part of licensure renewal in the majority of the 50 States in the USA.

Owning an X-ray machine likely resulted from the necessity from practicing a technique style that has image-guided specificity and not from simply wanting to gain income through taking needless radiographs (ethics) as insinuated by Jenkins et al.¹ We find it scientifically and professionally unacceptable, that Jenkins et al.¹ readily insinuate that

chiropractors use routine imaging merely as a profit generator; this type of unsubstantiated claim should not be allowed in the scientific literature unless concrete data supports it. The third reason why chiropractors continue to use X-rays is suggested as 'lack of education.'¹ Since chiropractors take multiple courses in X-ray physics, X-ray patient positioning, X-ray imaging, etc. it is not likely a lack of education. Only approximately 2.5% of a medical doctors' education is on musculo-skeletal health, while chiropractors graduate very competent in this area.¹¹⁰ Despite the ubiquitous fact that more research is needed regarding the practice of different chiropractic technique approaches, it is also a reality that published evidence is less developed for musculoskeletal disorders,¹¹¹ and any *lack of evidence does not mean evidence of ineffectiveness*.

As already discussed above, a seasoned chiropractor will possibly see many patients a year with pathologies only diagnosed by imaging and more appropriately treated by medical (not chiropractic) intervention raising the risk of liability over time as the reliance on 'red flag' only practice to rule out serious pathology has a lack of evidence for their diagnostic accuracy.¹¹² This is reason enough for routine initial X-ray imaging to avoid the inevitable delayed diagnosis/referral and proper treatment.

Section 3. Evidence of possible risks or limitations associated with the use of spinal X-rays

Jenkins et al. lists 4 main risks associated with spinal X-ray use:

- A. Radiation exposure
- B. Overdiagnosis
- C. Missed diagnosis
- D. Waste

A. Radiation exposure

Despite the long-held belief about radiogenic risks from X-rays, these are simply unfounded. This has been thoroughly discussed as it pertains to X-rays taken in the chiropractic profession elsewhere.^{44,94,108,109,113,114} There are several valid, evidence-based reasons why X-rays are not harmful, but the main reason which has recently come to light is that there is a very high dose-threshold for leukemia, the first cancer that would occur after a pathologic radiation exposure; this threshold is about 1100mGy.¹¹⁵ An X-ray of the spine ranges from 0.2mGy (cervical series) to 2-3mGy (whole spine series).⁴⁴ As demonstrated, there is a safety factor of 367 for a whole spine series and a safety factor of 5500 for a cervical series. Thus, X-rays do not cause cancer.

The other essential and overlooked notion in considering radiation risks from imaging is the true concept of radiation hormesis,¹¹⁶⁻¹¹⁹ and as stated in *Nature*: "the hormetic model is not an exception to the rule – it is the rule."¹¹⁶ If this concept is even acknowledged by medical-imaging 'radiation fear-mongers,' it is mentioned as an 'interesting theory,' for example as recently stated in a letter-to-the-editor by Jenkins and colleagues.⁴⁵ The fact is, hormesis occurs and it has been shown that any genetic damage created by low-dose medical imaging (DNA double strand breaks), is immediately (with 24

hours) repaired by the body's highly effective adaptive repair mechanisms;¹²⁰ referred to as 'innate intelligence' in the chiropractic literature. Thus, an X-ray of the spine, or several X-rays taken over months or years in the monitoring and managing of a patient will not contribute to the induction of cancer.⁹⁴ This fear mongering of misguided dangers of radiation from X-rays (and CT scans) needs to cease, and has been highlighted in many scientific exchanges (letters-to-the-editors) to recent articles claiming this association (medical imaging causing future cancers) - which it does not.¹²¹⁻¹²³

More fundamentally, the linear no-threshold (LNT) model as used by all the major national and international radiological protection agencies (NCRP, NAS BEIR, etc.) has recently been shown to have been originally adopted out of convenience and unethical misconduct by those involved in its initial adoption back in the 1950s.¹²⁴⁻¹²⁸ This surprising evidence revealed by Calabrese has fueled a challenge by various nuclear physicists, PhDs, medical doctors and other researchers (including the current authors), to abandon the antiquated LNT¹²⁹ which has only served to result in over-regulation and fear-mongering regarding any and all radiation exposures, including those that are negligible including X-rays.¹³⁰⁻¹³⁴

B. Overdiagnosis

The concern of overdiagnosis is a popular theme in current medical research. This is because, within medicine, it has been shown that diagnosing a patient with 'irrelevant' findings to their current complaint may lead to unnecessary further testing, possible unnecessary treatment, and patient anxiety.¹³⁵ The fact is, however, that those patients with spine deformity (whether symptomatic or not) are predisposed to future injury and impairment.¹³⁶ A patient has a right to know this information. Further, patients with spinal deformity also are predisposed to future worsening of their deformity and paralleled worsening of their quality of life.¹³⁷⁻¹⁴⁰

Due to the likely untoward health trajectory related to the progression of spinal deformity, a patient may choose appropriate choices (i.e. posture treatment, ergonomic strategies) to change this trajectory, just as a patient may choose to eat better once diagnosed with high blood pressure or type 2 diabetes. In fact, a patient may choose to receive treatment to improve their posture as a preventative measure just as surgeons do surgery on asymptomatic patients if they demonstrate spinal parameters linked to poor prognosis.¹⁴¹

The fact is not all chiropractors routinely X-ray their new patients as many practice generalized spinal manipulation, and not a particular spinal correcting technique per se. Since every patient has their own presenting posture and corresponding biomechanical parameters, it is only when these are compared to normative/ideal values relative to the patient's own morphology (pelvic morphology and thoracic inlet angle) can comparisons to appropriate threshold cut-offs and accurate biomechanical diagnoses be made.⁸² Thus, in general chiropractic practice it is obvious that 'overdiagnosis' is not occurring, but the underdiagnosis of relevant biomechanical structural deformity and subluxation patterns certainly is.

C. Missed diagnosis

Jenkins et al.¹ state that X-ray use has a high rate of false negative results (i.e. non-specificity for early pathologic changes). In other words, serious pathologies could be missed because the disease process has not progressed enough to have obvious presence on a spinal radiograph, such as in osteoporosis, where it cannot be detected on a plain radiograph until 30-50% of bone density loss has occurred. This may be true in the practice of general medicine, but is it worth minimizing many patients from the *false* fears of future carcinogenic harms to miss those few patients who have a true positive diagnosis? As Siegel states, probably not:

*true iatrogenic risk arises ... from misdiagnoses that are secondary either to patient refusal of medically indicated imaging or to nondiagnostic scans resulting from insufficient exposure.*¹⁴²

Jenkins cites 4 studies in this section to substantiate the medical approach. All 4 cited studies refer to the radiological diagnosis of metastases in general medical practice. However, as pointed out by us previously,^{108,109} because cancer rates are continuing to increase,¹⁴³ there is an ever-increasing chance of patients presenting with definitive malignancies. Recall Beck found the rate of x-ray diagnosed malignancies were as high as 1 in 32 patients!¹⁴ Thus, there is much more serious consequences of a 'missed diagnosis' in the event a chiropractor fails to X-ray a patient who has a serious pathology prior to delivering a high velocity-low amplitude force directly into those involved tissues vs. an MD prescribing medicine; in fact, there is no comparison.

A chiropractor missing a serious diagnosis such as malignancy raises obvious medico-legal and liability concerns. As eloquently stated by Underwood: "Malignancy is a diagnosis that practitioners would not wish to miss."¹⁴⁴ In fact, at the end of the day the old adage applies: 'no x-rays, no defense.'¹⁴⁵ Since X-rays are harmless (not carcinogenic), and since the practice of chiropractic is unique in that it demands a more comprehensive analysis of the spine and related tissues, x-rays end up being cost-effective in the long run as they are a fraction of the cost of the treatment itself, can lead to effective initial treatment as X-ray is the only way to effectively diagnose ASD, an epidemic with devastating health impact.^{80,81}

D. Waste

Contemporary evidence-based medical practice strives to eliminate wasteful practices, including the avoidance of routine imaging for ALBP.¹⁴⁶ This is because, in most cases, imaging does not alter the medical management of LBP as it pertains to the prescription of pharmaceuticals. In chiropractic however, it may be more wasteful to not X-ray initially. 'Waste' is really about cost-effectiveness. As discussed, more often than not, patients are not properly assessed for their biomechanical deformities, and therefore are left 'biomechanically' undiagnosed.

This leads to wasted treatment that usually is limited to cookie-cutter, 'black box' treatment, with patients of differing postural subgroups having varied temporal responses to the

same treatments. Long-term, a majority of these patients will continue to suffer and seek out more costly medical treatments, diagnostics etc. The cycle will likely continue where many will experience the waxing and waning of symptoms over many years. Many eventually receive spinal surgery. Spine surgery is not only costly, but has high rates of complications, hospital re-admissions, and unplanned reoperations;¹⁰³⁻¹⁰⁵ all these scenarios substantially adds to an individual's cumulative health care costs.

In this theoretical but often realistic back pain trajectory, one can appreciate if a proper biomechanical diagnosis (by routine full-spine radiography) was made initially, the patient could have been adequately and effectively treated (by biomechanical correcting methods) resulting in avoiding much wasted tests, treatments and suffering. Proper biomechanical diagnosis and treatment may have a dramatic cost-effectiveness over the often practiced 'black box' treatment of patients by 'cookie-cutter' conventional approaches (such as gross SMT) for all patients.

Section 4. Guidelines for the appropriate use of imaging

A rather anti-climactic ending to this review is the presentation of Table 1, 'Red Flag' guidelines. There is not much to discuss here as all red flags are fully taught in chiropractic college curricula and included in all X-ray guidelines. Red flags as a rationale to X-ray apply to all health care disciplines. It is interesting that in citing multiple references contributing to Table 1, their¹ 'summary of current evidence-based guideline recommendations for diagnostic imaging of the spine for chiropractors,' 7 out of the 8 references cited are allopathic medical guidelines (Table 1);¹⁴⁷⁻¹⁵³ only 1 reference⁹ is a chiropractic guideline.

The Bussieres et al.⁹ chiropractic guidelines have been criticized for being a recycled medical guideline in the guise of being created to be chiropractic specific, but they are not. Bussieres et al.,⁹ like Jenkins et al.,¹ fail to consider the unique requirements of the chiropractic analysis/treatment approach, the higher level of liability from treating by manual methods, as well as the understanding and critical importance of interrelated spinopelvic parameters that structural chiropractic approaches can address.

Conclusion

The review by Jenkins et al.¹ is a failed attempt to present 'current evidence for X-ray use in the chiropractic profession.' It represents just another, author opinion, 'red flag only' guideline consistent with the practice of medicine, not chiropractic. Ironically, while citing some key studies Jenkins et al.¹ fail to properly interpret implications of data from high-quality randomized trials that clearly demonstrates the superiority of X-ray-guided treatments for long-term patient outcomes beyond pain relief, including disability, HRQOL as well as other neuro-physiological benefits.

Critically, Jenkins et al.¹ failed to acknowledge the expansive understanding of spinopelvic biomechanical parameters (full spine and morphology measurements specific to the individual) that has occurred over the past 15 years and the fact that these critical parameters must be assessed by routine

full-spine radiography. The concept that spine and postural displacements of a patient impacts their health and wellbeing is a well framed evidence-based practice in the spine literature. Specific, contemporary chiropractic approaches, like contemporary spinal surgery techniques, can improve postural faults and restore normal function and wellbeing. To be valid, future chiropractic guidelines must include a consideration of the assessment of the critical spinopelvic parameters and the use of contemporary chiropractic methods used to correct these spinal subluxation deformities as detailed in this critique.

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Appendix

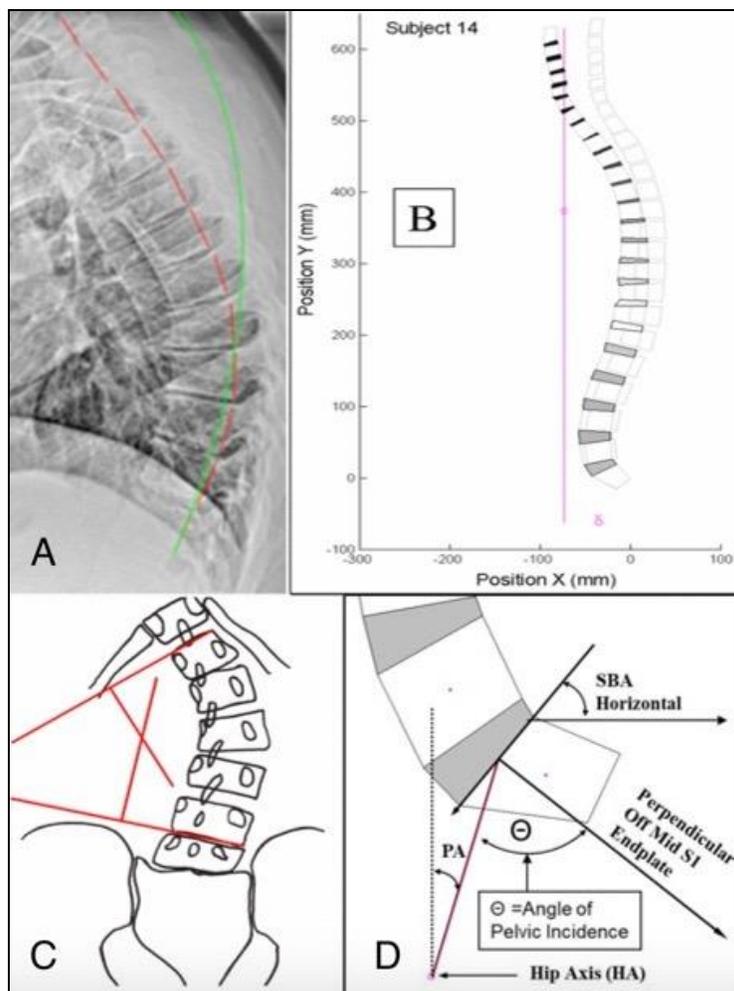


Figure 1A-D. Adult spine deformity specifically refers to the following spine deformity (subluxation) types as assessed with radiographic methods and present in any person 18 years and older:^{75,76,78,79,80} A) Thoracic hyper-kyphosis with a magnitude greater than 60° , green is ideal curve and red is patient kyphosis. B) Anterior (positive) sagittal balance of the C7-S1 plumb-line greater than 5cm (pink line from centroid C7 to horizontal offset of centroid S1). C) Any frontal view scoliosis of greater than 20° . D) Sagittal pelvic tilt angle (PA) greater than 25° . Note, due to the inverse relationship between this PA measurement and sagittal sacral base angle (SBA), PA is descriptive of a SBA being decreased where normal SBA = 40° , and normal PTA is approximately $17-18^\circ$. Thus, this measurement represents hypo-lumbar lordosis in the distal lumbar region.

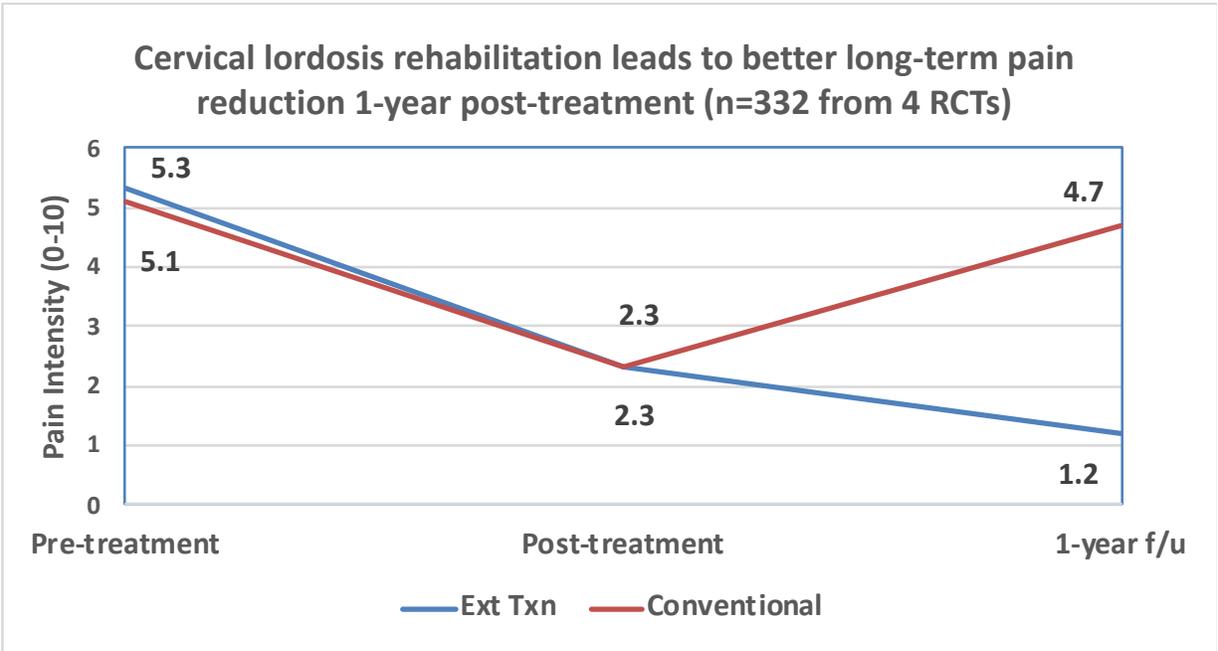


Figure 2. Spine-specific treatment shows better long-term symptom relief versus non-spine-specific conventional treatments. Data reported for the improvement of cervical lordosis and is weighted average from 4 RCTs.^{14-16,18} Note: Red line = conventional treatments (n=166); Blue line = conventional treatments plus extension traction to improve cervical lordosis (n=166). Y-axis = pain intensity (0=no pain; 10=worst pain ever).

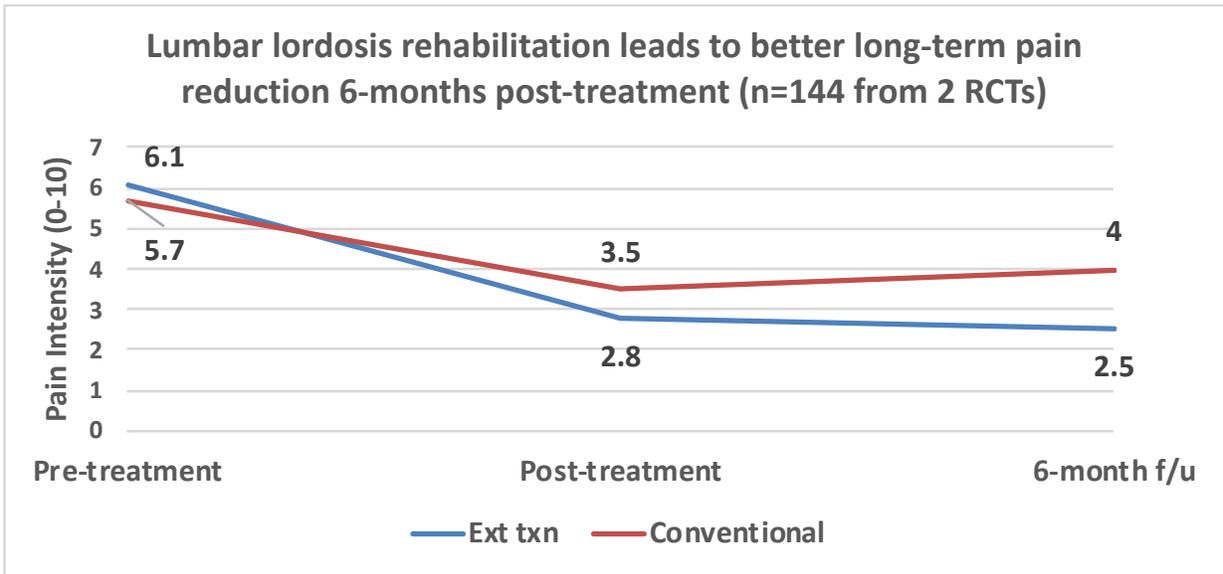


Figure 3. Spine-specific treatment shows better long-term symptom relief versus non-spine-specific conventional treatments. Data reported for the improvement of lumbar lordosis and is weighted average from 2 RCTs.^{12,13} Note: Red line = conventional treatments (n=72); Blue line = conventional treatments plus extension traction to improve lumbar lordosis (n=72). Y-axis = pain intensity (0=no pain; 10=worst pain ever).

Table 1. Details from 8 references Jenkins et al.¹ use in support of recommendations for the practice of ‘Chiropractic’ – All represent ‘Red Flags,’ none outline current spine biomechanics.⁸²

Author, year	Journal	Representative group	Intended provider	Condition
Chou, 2011 ¹⁴⁷	Ann Intern Med	American College of Physicians	MD	LBP
Stiell, 2001 ¹⁴⁸	JAMA	-	MD Emergency	Head/cervical trauma
Maher, 2017 ¹⁴⁹	Lancet	-	PCP - all	NSLBP
Horne, 2014 ¹⁵⁰	Am Fam Physician	-	MD	Scoliosis
Downie, 2013 ¹⁵¹	BMJ	-	PCP - all	Malignancy/fracture screening in LBP
RACOGP/OA, 2017 ¹⁵²	Published report	Royal Australian College of General Practitioners/Osteoporosis Australia	MD	Osteoporosis
Patel, 2016 ¹⁵³	J Am Coll Radiol	American College of Radiology	MD/radiologist	ALBP
Bussieres, 2008 ⁹	JMPT	-	Chiropractor	Spinal disorders

Note: Only one reference is from the chiropractic literature and is a known ‘red flag’ only guideline. PCP = primary care provider; A=acute/NS=non-specific/LBP=low back pain.