

DIAGNOSTIC IMAGING PRACTICE GUIDELINES FOR MUSCULOSKELETAL COMPLAINTS IN ADULTS—AN EVIDENCE-BASED APPROACH—PART 3: SPINAL DISORDERS

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ABSTRACT

Purpose: To develop evidence-based diagnostic imaging practice guidelines to assist chiropractors and other primary care providers in decision making for the appropriate use of diagnostic imaging for spinal disorders.

Methods: A comprehensive search of the English and French language literature was conducted using a combination of subject headings and keywords. The quality of the citations was assessed using the Quality of diagnostic accuracy studies (QUADAS), the Appraisal of Guidelines Research and Evaluation (AGREE), and the Stroke Prevention and Educational Awareness Diffusion (SPREAD) evaluation tools. The Referral Guidelines for Imaging (radiation protection 118) coordinated by the European Commission served as the initial template. The first draft was sent for an external review. A Delphi panel composed of international experts on the topic of musculoskeletal disorders in chiropractic radiology, clinical sciences, and research were invited to review and propose recommendations on the indications for diagnostic imaging. The guidelines were pilot tested and peer reviewed by practicing chiropractors, and by chiropractic and medical specialists. Recommendations were graded according to the strength of the evidence.

Results: Recommendations for diagnostic imaging guidelines of adult spine disorders are provided, supported by more than 385 primary and secondary citations. The overall quality of available literature is low, however. On average, 45 Delphi panelists completed 1 of 2 rounds, reaching more than 85% agreement on all 55 recommendations. Peer review by specialists reflected high levels of agreement, perceived ease of use of guidelines, and implementation feasibility. Dissemination and implementation strategies are discussed.

Conclusions: The guidelines are intended to be used in conjunction with sound clinical judgment and experience and should be updated regularly. Future research is needed to validate their content. (*J Manipulative Physiol Ther* 2008;31:33-88)

Key Indexing Terms: *Practice Guideline; Guideline; Diagnostic Imaging; Radiology; Diagnostic X-Ray; Radiography; Adult; Musculoskeletal System; Pain; Cervical Spine; Thoracic Spine; Lumbar Spine; Trauma*

REPORTING OF TOPICS INCLUDED IN THE DEVELOPMENT OF THE DIAGNOSTIC IMAGING PRACTICE GUIDELINES¹

An initial literature review considered 10 clinical questions pertaining to imaging of musculoskeletal conditions to evaluate the pertinence of developing diagnostic

imaging guidelines. This initial review led to a research project divided into 9 phases: (1) literature search; (2) independent literature assessment; (3) guideline development specific recommendations; (4) first external review; (5) consensus panel (modified Delphi); (6) public website; (7) second external review; (8) final draft and grading of the recommendations; and (9) dissemination and implementation. Details of this study are published elsewhere.²

Focus

These diagnostic imaging guidelines concern adult musculoskeletal disorders of the spine where conventional radiography and specialized imaging studies are deemed useful for diagnostic purposes. Special consideration for manual therapy intervention is integrated within these guidelines.

Objectives

Reasons for developing these guidelines include assisting current and future health care providers to make appropriate use of imaging studies, providing indications for the need of

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Paper submitted July 15, 2007; in revised form September 28, 2007; accepted October 14, 2007.

0161-4754/\$34.00

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doi:10.1016/j.jmpt.2007.11.003

imaging studies according to current literature, and expert consensus, and assisting in optimizing the utilization of limited available resources. These proposed guidelines are intended to reduce unnecessary radiation exposure and the use of specialized imaging studies, increase examination precision and decrease health care costs—all without compromising quality of care.

Target Users/Setting

Intended users of the guidelines are chiropractors and other primary health care providers prescribing diagnostic imaging studies. The setting in which these guidelines may be used include private clinics, outpatient clinics, and hospital emergency rooms.

Target Population

The patient population eligible for guideline recommendations are adult patients presenting with musculoskeletal disorders of the spine. Children and pregnant patients are excluded from these guideline recommendations.

Developers

The proposed guidelines are developed from the results of 9 distinct phases overseen by a research team composed of the 3 investigators with postgraduate education from 3 independent teaching institutions. The guidelines were further developed and peer reviewed by more than 60 chiropractic clinicians, academics, and researchers.

Evidence Collection

Electronic searches in English and French language literature occurred and cross references were repeated on 3 different occasions between 2003 and 2006.

METHODS FOR SYNTHESIZING EVIDENCE

- (a) Literature search and independent literature assessment of spinal disorders: Quality of diagnostic accuracy studies (QUADAS),³ Appraisal of Guidelines Research and Evaluation (AGREE),⁴ and Stroke Prevention and Educational Awareness Diffusion (SPREAD).⁵
- (b) Initial draft: template based on European Commission classification (2001).⁶
- (c) Expert consensus: a 2-round modified Delphi process was used to generate consensus among an international panel of more than 60 experts in musculoskeletal disorders.

Recommendation Grading Criteria

The evaluation tool used was designed by the Scottish Intercollegiate Guidelines Network (SIGN) and adapted by the Stroke Prevention and Educational Awareness Diffusion (SPREAD) group.^{5,7}

Patient Preferences

Condition specific imaging guidelines. Integral to evidence-based health care, decisions regarding the use of imaging studies should be based on the best available evidence, the

experience, and judgment of the clinician, while considering the patient preference. A public member reviewed all documents and provided comments and suggestions.

Stakeholders and Editorial Independence

- (a) *Prerelease review*: Before the release of the guidelines, the reliability of proposed recommendations was tested on specialists both in chiropractic and in medicine as well as on practicing chiropractors.
- (b) *Potential conflict of interest*: The research team involved in the development of these guidelines declare no existing or potential conflict of interest. No investigators have received nor will receive any personal financial benefits or derive any salary from this project.
- (c) Funding sources/sponsors:
 1. Canadian Memorial Chiropractic College Post Graduate Education and Research (2005)
 2. National Institute of Health Student Grant (2006)
 3. Canadian Chiropractic Protective Association (2006)

Updating/Revision

The literature review and the guidelines should be updated every 2 to 3 years.

Potential Benefits and Harm

Selection of appropriate radiologic imaging procedures for evaluation of patients with musculoskeletal disorders of the spine; decrease unnecessary ionizing radiation exposure, decrease costs, and improve accessibility.

Dissemination/Implementation Considerations

Publication; applying to National Guideline Clearinghouse; posting of the electronic document on various websites (malpractice insurance carriers, outpatient teaching clinics); educational intervention strategies (e-learning, community pilot studies); referral guidelines; reinforced by request checking and clinical management algorithms; promotion by national, provincial and state organizations, conferences.

Definitions, Patient Presentations, Recommendations, and Rationale

These topics are integral parts of each 1 of the 3 diagnostic imaging guidelines: lower extremity disorders, upper extremity disorders, and spine disorders. Results of the 9 phases of the research project are published elsewhere.²

PRELIMINARY CONSIDERATIONS AND DISCLAIMER

What Is the Role of These Guidelines?

These evidence-based diagnostic imaging practice guidelines are intended to assist primary care providers and students in decision making regarding the appropriate use of diagnostic imaging for specific clinical presentations. The guidelines are intended to be used in conjunction with sound clinical judgment and experience. For example, other special circumstances for radiographic imaging studies may include: patient unable to give a reliable history; crippling cancer phobia focused on back pain; need for immediate decision

about career or athletic future or legal evaluation; history of significant radiographic abnormalities elsewhere reported to patient but no films or reliable report reasonably available; history of finding from other study (eg, NM or gastrointestinal imaging) that requires spine radiographs for correlation.⁸ Application of these guidelines should help avoid unnecessary radiographs, increase examination precision, and decrease health care costs without compromising the quality of care.

The descriptions of clinical presentations and proposed clinical diagnostic criteria, recommendations for imaging studies, and the comments provided throughout this document are a synthesis of the vast body of literature consulted before and during the various phases of this research project. Where the literature was found to be of poor quality or absent, consensus based on expert opinion was used. Although the investigators and collaborators carefully searched for all relevant articles, it is probable that some have been missed. Furthermore, as many new important studies are published in the near future, these will be incorporated in subsequent revisions of the guidelines and recommendations may change accordingly.

What These Guidelines Do and What They Do Not Do

It should be emphasized that these guidelines were developed with the intent of being used for diagnostic purposes and not for therapeutic purposes such as evaluating and monitoring functional or structural rehabilitation of the spine.⁹ In addition, these guidelines are intended to address issues faced by first contact professionals only. These guidelines do not address all possible conditions associated with musculoskeletal disorders, only those that account for the majority of initial visits to a practitioner.

Like other diagnostic tests, imaging studies should only be considered if (a) they yield clinically important information beyond that obtained from the history and physical examination; (b) this information can potentially alter patient management and; (c) this altered management has a reasonable probability to improve patient outcomes.¹⁰⁻¹²

Investigators and collaborators in the development of these imaging guidelines believe that liability insurance companies, third-party payers, and courts of law should not rely solely on descriptions of patient presentations, proposed recommendations, and/or corresponding comments found throughout the documents, as patient presentations are unique and the application of any guideline always requires clinical judgment and thus needs to be considered in the proper context. In addition, laws and regulations may vary between geographical regions and should be considered when applying the proposed indications for any imaging study.

What Is Evidence-Based Health Care?

Evidence based is about tools, not about rules.¹³ Evidence-based health care is an approach in which clinicians and health care professionals use the current best evidence in making decisions about the care of patients. It involves continuously

and systematically searching, appraising, and incorporating contemporaneous research findings into clinical practice. The overall goal is improving patient care through life-long learning.^{13,14}

Potential Disagreements

There are several reasons for disagreement within a guideline development group. These include differences in interpretation of the research literature, differences in personal experience, and different perceptions of the inherent risks and benefits of a procedure.¹⁵ Divergent or competing guidelines on similar topics serve only to further confuse and frustrate practitioners.¹⁶ In addition, the continued lack of unity among chiropractors hinders its growth by limiting integration and cooperation within the greater health care system. Readers of all guidelines are advised to critically evaluate the methods used as well as the content of the recommendations before adopting them for use in practice.¹⁷

Standard Patient Management Activities

Standard patient management activities, including diagnostic assessment and follow-up, are integral components of every patient encounter.¹⁸ Initial triage of patients with spine disorders is a constant recommendation of various clinical guidelines.¹⁹ Imaging studies are used most practically as confirmation studies once a working diagnosis is determined. The objective is to determine the presence of clinical indicators of serious pathologies (red flags) requiring diagnostic imaging, specialist referral or urgent surgical intervention. When a practitioner recommends that a radiograph or other diagnostic imaging study be performed, and the patient refuses, the patient should be advised of the associated risks and implications and this should be recorded in the patient's records.

Duration of Disorders

In clinical practice, spine disorders are generally divided into categories according to the duration of the patient complaint on initial presentation. These diagnostic imaging guidelines therefore consider the following categories of clinical presentations: acute spine disorder (<4 weeks' duration); subacute spine disorder (4-12 weeks' duration); and persistent/chronic spine disorder (>12 weeks' duration).

Defining Radicular Pain

It is generally accepted that patients with neurologic symptoms and signs (pain radiating below the knee or beyond the elbow, as intense as the low back or neck pain, often radiating into the foot or hand with numbness or paresthesia in a dermatomal distribution with positive nerve root tension signs, abnormal motor power, sensation or deep tendon reflexes consistent with a nerve root involvement) have a slower resolution than patients with uncomplicated spine disorders (mechanical pain that varies with time and activity with no neurologic component and a good general health status). Again, clinical presentations are divided accordingly throughout these imaging guidelines.

Table 1. Thoracolumbar, lumbar, and thoracic spine trauma

Patient presentation	Recommendations	Comments
Adult patient with recent (<2 wk) acute thoracolumbar, lumbar or thoracic spine trauma. Absence of pain, normal ROM, and absence of neurologic deficits (normal lower limb motor power, sensation and deep tendon reflexes, and no pathologic reflexes).⁶	Radiographs not routinely indicated [C]	In a recent survey, 53% of patients consulting chiropractors reported having an injury. The most common reported source was non-work related (43%); work-related injuries accounted for only 16%, and 21% were classified as nonspecific.⁴¹ Physical examination is reliable in this region. When the patient is alert and asymptomatic, injury risk is low and radiographs provide no clinical utility.^{6,42} Increased prevalence of traumatic fractures found in patients >75 yoa. Prevalence of lumbar spine traumatic fracture is <1% but overall prevalence of spine fractures for all age groups is 4%.^{43,44}
Adult patient with thoracolumbar, lumbar, or thoracic spine blunt trauma or acute injuries (falls, motor vehicle accidents [MVAs], motorcycle, pedestrian, cyclists, etc) High-risk screening criteria for spinal injuries include any of the following⁴⁵⁻⁴⁹: 1. Back pain 2. Midline tenderness on palpation 3. Distracting painful injury and other high-risk mechanism of injury* 4. Neurologic deficits** 5. Altered consciousness (caused by head trauma, intoxication/ethanol, or drugs) <i>Sensitivity of 100 % (95% CI, 98%-100%) but low specificity and low positive predictive value for thoracolumbar injuries.</i>	Radiographs indicated [B] Lumbar AND thoracic spine: AP (or PA), lateral views N.B. The high-risk screening criteria for spinal injuries was developed to help determine the need for plain film radiography in the emergency room. The lower prevalence of serious post traumatic injuries in ambulatory care likely influence the sensitivity of such instruments. Nonetheless, it appears reasonable to recommend their use in primary care as well.	Conventional radiography is highly specific but has a sensitivity of ≈ 0.70 and a predictive value of 0.92⁴⁵ Thoracic and lumbar spinal injuries affect 2%-3% of blunt trauma victims with a 40%-50% incidence of neurologic deficits.⁷ Major spine traumas are typically seen in hospital settings and mandate immobilization pending radiographic evaluation. Missed spinal injuries resulting in neurologic deficit continue to occur in major trauma centers. Older age (>50), high impact accidents, patients with insufficient imaging, and misread or poor quality radiographs are at highest risk of missed injuries.⁵⁰ The Thoracolumbar Injury Severity Scale (TLISS) may be helpful in the referral decision making process. The scale is based on the mechanism of injury, the integrity of the posterior ligamentous complex, and the neurologic status.⁵¹⁻⁵³ (See Appendix C(1) for details)
* High-risk mechanism of injury: Severe mechanism of injury (falls ≥ 10 ft/3 m, ejection from a motor vehicle, and motor vehicle crashes >50 mph/80 km) and the presence of cervical spine fracture are significantly associated with an increase risk of thoracolumbar spine injury. ** Neurologic deficits: a. <i>Lumbar spine injuries:</i> positive nerve root tension signs decreased motor power, sensation, and/or deep tendon reflexes. b. <i>Thoracolumbar and thoracic spine injuries:</i> lower limb spasticity, presence of pathologic reflexes (Babinski sign/clonus), altered sensations below the injury (sensory level), and altered proprioception (vibration/position sense of the feet), loss of anal sphincter tone. • Patient with spinal injuries may suffer progressive neurologic deterioration, and imaging again has a role in their diagnosis and management.⁷	Special investigations [C]	Advanced imaging and specialist referral recommended: a. In presence of a fracture as suggested by history, examination, and/or radiograph. Special attention required in presence of complex lesions and for suspected ligamentous instability or neural injuries; b. If conventional radiographs are difficult to interpret; c. In the absence of clinical improvement after 4-6 wk of therapy; d. Function does not improve or deteriorates; e. Patient has persistent S&S. • CT scan (multidetector/multislice CT and spiral CT) highly sensitive (99.3%-100%); specificity of 97%; negative predictive value of 92%^{47,48,54,55} • MRI provides the best evaluation for soft tissue pathology, intrinsic or compressive spinal cord damage and multilevel vertebral fractures. MRI needed when conventional radiographs and CT do not explain patient's symptoms, and when there is a possibility of epidural hematoma or traumatic disc herniation⁵⁶
For osteoporotic fracture risk, please see Pain—Osteoporotic Vertebral Collapse section of the Adult Thoracic Disorders Guideline.		

Table 1 (*continued*)

Patient presentation	Recommendations	Comments
Adult patient with posttraumatic chest wall pain Minor trauma⁶ Major trauma⁶	Radiographs not routinely indicated [D] Radiographs indicated [GPP] PA, lateral chest radiographs, Specific rib radiographs (AP, oblique) Additional views: PA chest in full expiration, Thoracic and /or lumbar spine views Special investigations [GPP]	Although difficult to visualize, presence of a rib fracture would alter the treatment plan in manual therapy. Chest radiographs frequently underestimate the severity and extent of chest trauma, and in some cases, fail to detect the presence of injury. CT is more sensitive than chest radiography in the detection of pulmonary, pleural, and osseous abnormalities.⁵⁷ Penetrating injuries or clinical findings suggestive of significant air exchange difficulty urgently require more extensive work-up. Advanced imaging and specialist referral recommended: • CT for sternum injury, pulmonary, pleural, and osseous abnormalities⁵⁷
Adult patient with pelvis and sacrum trauma (including falls with inability to bear weight)⁶ The diagnosis of sacral fractures is frequently missed or delayed, and the treatment is controversial, with significant variations in recommendations regarding nonoperative treatment, neural decompression, and internal fixation.⁵⁸ Posterior pelvis physical examination, especially palpation, may accurately detect injuries to the posterior pelvic ring.⁵⁹ Look for ecchymosis. However, physical examination may not be reliable for other pelvic injuries.	Radiographs indicated [D] AP Pelvis and lateral hip “frog leg” Additional views: (1) Lateral lumbar view to better visualize the lateral sacrum (2) Angulated AP or PA sacrum view (15°–45° tube angulation) Special investigations [D]	Be aware that femoral neck fracture may not be visible on initial radiographs even with a good lateral view of the hip. Factors that may impact treatment outcomes include the level and type of sacral fracture, lumbosacral junction and sacroiliac joint involvement, and associated pelvic ring injury.⁵⁸ Advanced imaging and specialist referral recommended • NM, MRI, or CT may be helpful if radiographs are normal or equivocal.⁶ • Imaging measurement parameters used to evaluate sacral injuries may include AP sacral fracture displacement (axial CT of the pelvis), vertical sacral fracture displacement (coronal CT reconstruction), AP translation and kyphotic angulation (sagittal CT reconstruction), and degree of central canal involvement and foraminal encroachment (axial, coronal, and sagittal CT reconstruction)⁵⁸
Coccyx trauma and coccydynia Consider taking radiographs if unrelieved by initial rest or if manual treatment of this area is contemplated. • Obesity, a history of trauma, and transient exacerbation of the pain when standing up from sitting may be associated with posterior dislocation. • Coccyx pain may be referred from a fracture of the distal sacrum. In doubt, consider views of the sacrum if distal sacrum fracture is suspected.^{60–62}	Radiographs not routinely indicated [C] (Spot AP, lateral coccyx)^{6,63} Additional views: AP, lateral sacrum Dynamic sitting lateral views of the coccyx⁶⁴	Normal appearance often misleading.⁶³ Look for fractures, dislocations, and hypermobility (coccygeal mobility between 5° and 25° is considered normal).⁶¹

Table 2. *Cervical spine trauma*

Patient presentation	Recommendations	Comments
Adult patient with acute neck injury and negative CCSR (Canadian Cervical Spine Rule for Radiography in Alert and Stable Trauma Patients)⁶⁵⁻⁶⁸ Conventional radiographs are unlikely to show clinically significant injuries when <i>all Canadian Cervical Spine Rule</i> criteria are fulfilled⁶⁵⁻⁶⁹	Radiographs not routinely indicated [B] N.B. The CCSR and NEXUS instruments are highly sensitive clinical decision rules developed to help determine the need for plain film radiography in the emergency room. The lower prevalence of serious post traumatic injuries in ambulatory care likely influence the sensitivity of such instruments, nonetheless, it appears reasonable to recommend their use in primary care as well.	Whiplash incidence is between 70 and 360 cases per 100 000.⁷⁰ Traumatic unstable injuries are rare (<3%). The CCSR⁶⁵ is superior to physician judgment, more sensitive and specific than the National Emergency X-Radiography Utilization Study criteria/NEXUS^{66,67} In head-turned rear impacts up to 8 g peak acceleration, the alar, transverse, and apical ligaments are not at risk for injury.⁷¹
(A) Any high-risk factors in alert and stable patient? 1. Age >65 (see NEXUS in comment section) 2. Dangerous mechanisms of injury* 3. Paresthesias in extremities		Although patients >65 yoa are more prone to cervical spine fractures, data from NEXUS indicates that being >65 is not, by itself, a risk factor if all criteria are considered.^{7,72} (Sensitivity 100% (95% CI.) Cervical spine radiographs are not indicated <i>if</i> patients fulfill <i>all 5 NEXUS low-risk criteria</i> for head and/or cervical spine trauma⁶⁷: (1) Normal level of consciousness (may be temporally confused, have mild dizziness or headache) (2) No evidence of intoxication (3) Absence of tenderness on palpation of the midline of the neck (4) Absence of focal neurologic deficit (5) Absence of painful traction injury
(B) Any low-risk factors that allow ROM assessment? 1. Simple rear end collision** 2. Patient seated in the waiting room 3. Ambulatory at one time since trauma 4. Delayed cervical pain onset 5. Absence of midline cervical tenderness		
(C) ROM assessment: Is patient able to actively turn his/her head to 45° in both directions?		
* Dangerous injury mechanism: • Fall >3 ft/5 stairs • Axial cranial force (such as diving) • Road accident >100 km/h, ejected from vehicle or rollover • Motorized recreational vehicle (ATV, snowmobile, etc)		Rare injuries may be missed, when the CCSR or NEXUS is properly applied, findings are generally considered not clinically significant^{65,67}; spinous or transverse process fracture, <25% single anterior compression fracture, isolated avulsion injury not associated with ligamentous injury, type I odontoid fracture, end plate fracture, osteophyte fracture excluding teardrop or corner fracture, trabecular bone injury.
** Rear end collision excludes: • Being pushed into oncoming traffic • Hit by a bus or large truck • Rollover • Being hit by high speed vehicle (≥100 km/h)		NB. "Not clinically significant missed injuries" may be relevant to manual therapy practitioners. However, considering soft tissue and bone healing time; recommendations include early activation and a gradual progression from mobilization to SMT. SMT recommended only when patient can tolerate pre-SMT position test.⁷³⁻⁸² Of interest, the hypothesis that early aggressive conservative care promotes faster recovery was not supported in a recent population-based cohort study⁸³
Sensitivity 100% (95% CI, 98%-100%) and specificity 42.5% (95% CI, 40%-44%).^{65,66}		

Table 2 (continued)

Patient presentation	Recommendations	Comments
Adult patient with acute neck injury and positive CCSR (Canadian Cervical Spine Rule for Radiography in Alert and Stable Trauma Patients)⁶⁵⁻⁶⁸ Any adult patient not fulfilling all criteria of the CCSR must undergo cervical spine radiographs: (A) Age >65; dangerous mechanisms of injury; paresthas in extremities (B) Not a simple rear end collision; patient unable to sit in the waiting room; not ambulatory at one time since trauma; immediate cervical pain onset; presence of midline cervical tenderness (C) Patient unable to actively turn his head to 45� in both directions Both physical and psychological factors play a role in recovery or nonrecovery from whiplash injury.^{84,85} Finally, an important association exists between a history of whiplash associated disorders (WAD), pain intensity and disability and comorbidity (headache, LBP, digestive, and cardiovascular disorders).⁸⁶⁻⁸⁸ <i>Patient history may include:</i> • Patient age and sex • Pain location/radiation • Delay in S&S appearance • Mechanism of injury • Use of relevant psychometric questionnaires: NDI for neck disability, psychological distress (General Health Questionnaire 28, fear of movement/re-injury (TAMPA Scale of Kinesophobia, TSK), acute post-traumatic stress (impact of events scale and general health and well being [Short Form 36, SF-36]). • a complete system review <i>Patient physical examination may include:</i> • motor function* including cervical ROM and manual spinal palpation • a thorough neurologic examination, including cranial nerves, motor power, deep tendon reflexes, and local and general sensory testing. The above information helps determine the severity of the injury and prognosis. See Appendix C(2) for a modified classification system for acute WADs including physical and psychological impairments. *Motor system function testing may also include muscle recruitment pattern, joint position error, EMG recording, kinematic analysis of the cervical spine, and quantitative sensory testing/algometry.⁸⁹	Radiographs indicated [B] APOM, AP lower cervical, neutral lateral N.B. The CCSR and NEXUS instruments are highly sensitive clinical decision rules developed to help determine the need for plain film radiography in the emergency room. The lower prevalence of serious post traumatic injuries in ambulatory care likely influence the sensitivity of such instruments, Nonetheless, it appears reasonable to recommend their use in primary care as well. Additional views [GPP] CT now considered superior to and should replace oblique, pillar, dynamic flexion/extension (F/E) in suspected fracture. Special investigations [C] CT is becoming the primary investigation for high risk patients on an emergency basis (more accurate, faster, and need less patient mobilization compared with conventional radiography).^{54,90,91} Harboview CT Screening Criteria (prediction rule): • High energy trauma • Severe head injury • Focal neurologic deficit • Associated injury • Age (>50 y) • If patient >65 yoa, consider moderate-energy mechanism⁹²	Conventional radiographs may be difficult to assess; view must clearly include C7-T1 and the odontoid.⁹³ Pertinent 3 view radiological findings: • ADI >3 mm in adults (>5 mm in children) • Acute intradiscal vacuum cleft • Acute angular segmental kyphosis • Widened spinous process interspaces • Loss of facet parallelism • Presence of prevertebral edema without fracture.⁹⁴ According to the Yale criteria, a sagittal translation >3.5 mm or >11� of sagittal rotation in adults indicates segmental instability & requires surgical fusion.⁹⁴ See Appendix C(2) for a new classification of lower cervical spine injuries (Cervical Spine Injury Severity Score)⁹⁵ Cervical spine immobilization in awake patient with persistent pain or tenderness and normal initial standard 3-view series (including supplemental CT as necessary) to exclude ligamentous instability may be discontinued after either⁹⁶: (a) normal dynamic flexion/extension (F/E) radiographs as achieved by the patient with no assistance and under proper supervision (consider fluoroscopy) (b) a normal MRI study is obtained within 48 h of injury NB. F/E films may add little value to the acute evaluation of patients with blunt trauma due to muscular spasm. Consider F/E imaging delayed to 14-28 d postinjury when muscular spasm has resolved.^{97,98} Specialist referral is highly recommended in blunt trauma and trauma patients with neurologic signs or fractures/dislocations. In moderate- to high-risk trauma, delays in diagnosis of clinically significant C/S injuries range between 5% and 23%, most of which used conventional radiography as initial screening modality. Neurologic deterioration occurs in 10%-50% of these patients.⁴⁷ • Consider MDCT (multidetector/multislice CT) or MRI in blunt trauma or if initial radiographs are difficult to interpret or in presence of complex lesions. • MRI for suspected ligamentous instability or neural injuries. In the presence of neurologic S&S, examine patient for signs of acute myelopathy. EMG may be useful.⁶ • Consider CT for occult fractures.⁹⁸

(continued on next page)

Table 2 (continued)

Patient presentation	Recommendations	Comments
<i>The reader is referred to Foreman & Croft textbook Whiplash Injuries⁷³ and the Quebec Task Force on Whiplash-Associated Disorders⁷⁴ for additional reading on WAD</i>	However, MRI is an acceptable option.	The presence of any one of the following parameters places the patient in the high-risk category (>5% risk of cervical spine fracture) and indicates that the patient should undergo helical CT⁹⁰: 1. High-speed (35 mph [56 km/h] combined impact) MVA 2. Crash with death at scene of MVA 3. Fall from height (10 ft [3 m]) 4. Significant closed head injury (or intracranial hemorrhage seen on CT) 5. Neurologic symptoms or signs referred to the cervical spine 6. Pelvic or multiple extremity fractures See Cervical Artery Dissection section for further details on prior history of major trauma.

Table 3. Nontraumatic lumbar spine disorders

Patient presentation	Recommendations	Comments
General background information Standards of care dictate that careful history & physical examination be done routinely for all patients. See Lurie (2005)⁹⁹ for a comprehensive review of the value of the history & physical examination for LBP. Between 41% and 44% of initial chiropractic visits are for low back–related complaints, of which 45% are acute in origin.^{41,100}		Low back pain on initial presentation is typically classified according to the duration of complaint and type of presentation: uncomplicated/nonspecific LBP, associated with neurologic deficits or to some underlying pathology.¹⁰¹ Duration of complaint: Acute LBP: <4 wk of duration Subacute LBP: 4–12 wks' duration Persistent/chronic LBP: >12 wks' duration The cumulative 6-mo incidence of LBP is 18.6% (95% CI, 14.2–23.0) with 17.2% having mild pain (95% CI, 12.9–21.5), 1.0% having intense pain (95% CI, 0.0–2.2), and 0.4% disabling pain (95% CI, 0.0–1.0).¹⁰² Annual course of back pain is as follows¹⁰²: • 27.3 of low back complaints resolve • 29% improve • 35.4% persist • 9.3 get worse • 31.3% recur
Adult patient with acute uncomplicated* LBP (<4 wks' duration) * Uncomplicated definition: nontraumatic LBP without neurologic deficits or indicators of potentially serious pathologies—(see red flag list for details).	Radiographs not initially indicated^{42,101,108,109} [B]	Routine use of lumbar spine conventional radiography is not indicated because of very low incidence of unexpected findings on radiographs (only 1 in 2500 radiographs), high radiation dose to gonads, high cost/benefit ratio, and poor association between patient findings and LBP (ie, not specific). Anomalies of no proven clinical relevance include block vertebrae, spina bifida occulta, mild scoliosis, and facet tropism; none of which are considered contraindications to SMT.^{40,43,110–136}
Mechanical LBP accounts for the vast majority of LBP seen in primary care setting. Mechanical designates anatomical or functional abnormality without an underlying pathology.⁴⁴ For most young or middle-aged adults, early diagnostic evaluation of low back complaints may focus on 3 basic questions: diagnostic imaging is infrequently required.⁴⁴ 1. Is there underlying systemic disease?	Special investigations not indicated [B] Outside the setting of suspected systemic disease or neurologic compromise, radiography, scintigraphy, computed-tomography (CT), and MRI add very little to the diagnostic evaluation of LBP.^{42,99}	Several factors influence the reliability and validity of biomechanical and postural analyses on conventional radiographs: Morphologic asymmetries, geometric and positional distortions, measurement errors, poor correlation with symptoms and lack of convincing clinical usefulness.^{43,105,106,121,122,137–145} Acute LBP is generally due to musculoskeletal conditions that respond favorably to SMT.^{146,147} A multidisciplinary panel recommended 2 trial courses of 2 wk each, using

Table 3 (continued)

Patient presentation	Recommendations	Comments
2. Is there neurologic impairment that might require surgical intervention? 3. Is social or psychological distress amplifying or prolonging the pain? There is strong evidence that in nonspecific LBP, conventional radiography and MRI findings do not correlate with clinical symptoms or work capacity.^{103,104} In the <i>absence</i> of red flags as revealed by the history and physical exam, radiography in patients with LBP of at least 6 wk duration is not associated with improved physical functioning, severity of pain, disability, or overall health status. Conventional radiography may somewhat improve patient satisfaction. However, minor psychological improvement should be balanced against radiation dose, higher number of doctor visits, and increased disability at 3 mo.¹⁰⁵⁻¹⁰⁸		alternative manipulative procedures.^{148,149} Lumbar spine radiography recommended in the absence of expected treatment response or worsening after 4-6 wk. Serious adverse events are unlikely to occur with chiropractic treatment for LBP.¹¹⁵ Contraindication for lumbar SMT includes progressive neurologic deficits, S&S of cauda equina syndrome, suspicion of abdominal aortic aneurysms or destructive and bone softening diseases such as Paget's disease, and severe osteoporosis. (<i>See LBP with red flag's for details</i>).
Adult patient with uncomplicated subacute (4-12 wks' duration) or persistent LBP (>12 wks' duration) AND no previous treatment trial.^{63,101} Consider a clinical evaluation of risk factors for chronic LBP (<i>yellow flags</i>). Look for functional disability, significant depression, and risk profile for delayed recovery. A trial of 4-6 wk of conservative care is appropriate before radiographs.	Radiographs not initially indicated [B]	As with all cases, recent previous available radiographs should be reviewed by the clinician. Overall, studies have not shown any significant correlation between posture and LBP. Degenerative processes (disc & facet) are common & usually related to age (prevalence >62% in patients >55 yoa). Degenerative processes may account for 10% of all LBP. Abdominal aortic calcification may be associated with lumbar disc degeneration, back pain. However, even if DJD and DDD are present, clinical management remains essentially unchanged.^{42,43,113,121,150-156}
Adult patient with nontraumatic acute LBP (<4 wks' duration) AND sciatica (no red flags)^{6,63,101} The first clinical clue to neurologic impairment usually is a history of sciatica: sharp pain radiating down the posterior or lateral aspect of the leg, often associated with numbness or paresthesia.	Radiographs not initially indicated [B]	The natural course of acute sciatica caused by lumbar disc herniation (LDH) is benign as most patients improve during the first 4 wk,¹⁵⁷ whereas 5%-25% are recurrent or persistent.^{158,159} Patient S&S should not increase while in the premanipulative side posture, in which case SMT should not be attempted. Treatment approach should be adapted to further reduce complication risks.^{160,161} Ongoing clinical assessment is necessary each visit to detect any early signs of CES.^{162,163} — (<i>see red flags for details</i>).
Specific clinical diagnoses:		
Common causes of sciatica Historical and physical findings are the key factors in assessing neurologic compromise.⁹⁹ (A) Suspected LDH^{44,163-170}: • Symptomatic LDH represents 4%-5% of causes of LBP • Risk factors for LDH include: men (1.6 times more likely), middle-aged (35-54 yoa), repetitive heavy lifting, current smoking, obesity (high BMI), and type of occupation. • Predominantly leg pain, typically involving the foot • >95% of clinically important LDH involve the L5 or S1 nerve root. • Straight leg raise is sensitive (0.8) but nonspecific (0.5);	Radiographs not initially indicated [B] Unless patient age >50 or has progressive neurologic deficits LDH cannot be seen on conventional radiography. Special investigations not initially indicated [C] (<i>see Suspected causes of sciatica for details</i>)	The natural course of acute sciatica caused by LDH is favorable.¹⁵⁷ A trial of conservative care may first be attempted.^{171,172} SMT appears to be a safe & effective treatment for nonprogressive S&S of lumbar disc protrusion, especially when compared to common treatments for LDH, such as NSAIDs and surgery.^{160,161,173-180} It is estimated only 2% of all patients who have LBP will undergo surgery for disc herniation, representing 5%-10% of all cases of LDH.^{166,176} MRI <i>within the first 4-6 wk</i> of suspected LDH is necessary only if there is progressive neurologic deficit or intolerable pain levels despite conservative care and surgical referral is planned.⁹⁹ Disc abnormalities may be classified on MRI according to the following:

(continued on next page)

Table 3 (*continued*)

Patient presentation	Recommendations	Comments
• Crossed SLR is highly specific (0.8) but not sensitive (0.3) • Look for lower limb sensory, motor, and reflex deficits See Appendix C(3) for a detailed list of clinical criteria for LDH.		Modic classification¹⁸¹: 4A—herniated disc protrusion with an intact annulus; 4B—extrusion with rupture of either the annulus or the posterior longitudinal ligament, or both (extrusion appears to be rare in asymptomatic adults); 4C—rupture of the annulus and the posterior longitudinal ligament with sequestration of a disc fragment in the spinal canal.
(B) Suspected degenerative spondylolithesis/lateral stenosis • Back pain with or without leg pain • Increase pain with activity • S&S with or without neurologic deficit	Radiographs indicated if patient age >50 or has progressive neurologic deficits: PA (or AP), lateral lumbar views [GPP] Special investigations not initially indicated [C] (see <i>Suspected causes of sciatica</i> for details)	If clinical signs suggest instability: <i>please see special investigations in: Re-evaluation of LBP for critical exclusionary diagnoses.</i> • A trial of conservative care may first be attempted
(C) Suspected lumbar degenerative spinal stenosis (3% of all LBP)^{99,182,183}: • MC >65 yoa (sensitivity of 0.7; specificity of 0.69) • Neurogenic claudication: severity of back and leg pain commonly increase with ambulation/standing/walking downhill and improve while seated (flexed spine). Absence of pain when seated, rather than improved pain, has low sensitivity (0.46) but is very specific (0.93); • Variable neurologic deficit (numbness, weakness)	Radiographs indicated if patient age >50 or has progressive neurologic deficits: PA (or AP), lateral lumbar views [C] Special investigations not initially indicated [C] (see <i>Suspected causes of sciatica</i> for details)	Conventional radiography is of limited value in assessing spinal stenosis. As many as 20% of asymptomatic adults >60 yoa have imaging evidence of spinal stenosis and the prevalence of symptomatic stenosis is unknown.^{44,99} Spinal stenosis may be caused by bone (facet hypertrophy, osteophytes, etc), soft tissue (bulging disc or thickened ligamenta flava, etc), or both. • A trial of conservative care may be attempted first.
Suspected causes of sciatica: (A) Lumbar disc herniation (B) Degenerative spondylolithesis/lateral stenosis (C) Lumbar degenerative spinal stenosis Results from specialized imaging should always be interpreted in light of the clinical findings. Inappropriate utilization of these highly sensitive examinations will produce false-positive results which may result in labeling of patients and contributing to an unfavorable prognosis.^{99,101,184}	Special investigations not initially indicated^{6,166,185} [C]	Comanagement or specialist referral recommended even if conventional radiographs are unremarkable: 1. After failed conservative therapy (4-6 wk) 2. For preoperative planning; 3. If neurologic status is deteriorating (progressive deficit, disabling leg pain)^{186,187}; • New disc extrusion and nerve root impingement may be the most important findings on MRI^{135,188} • Substituting rapid MRI for radiographic evaluations in the primary care setting may offer little additional benefit to patients, and it may increase the cost of care because of the increased number of spine surgeries that patients are likely to undergo.^{134,188,189} • <i>MRI sensitivity (0.6-1.0) & specificity (0.72-0.99) for LDH is slightly higher than those for CT (0.62-0.9 & 0.7-0.87) but very similar for the diagnosis of spinal stenosis (0.9 & 0.72-0.99)</i>⁴⁴
Adult patient re-evaluation in the absence of expected treatment response or worsening after 4 to 6 wk Should patient fail to improve as expected or marginally improve within 4-6 wk of initial evaluation, the clinician must review history and physical findings and request appropriate diagnostic imaging studies.^{42,44,99,101,108,109,189-191}	Radiographs indicated [B] PA (or AP), lateral lumbar views Additional views not routinely indicated [C] a. Lateral lumbosacral spot	Probability of encountering disease requiring specialized therapy in patients with LBP using conventional radiography is <0.2 in 100 and the probability of tumors or infection would be <1 in 1000.^{43,196,197} a. If poor visualization of lumbosacral junction on lateral view

Table 3 (continued)

Patient presentation	Recommendations	Comments
Adaptation of the plan of management partly relies on the ability to predict patient disability status or long-term return to work status. ¹⁹¹⁻¹⁹⁵ Patient perception of the likelihood of returning to his/her usual activities should be measured after 4 wk of disability or at the time of first consultation if the patient has a history of persistent spinal pain with prolonged disability. Validated questionnaires are available to help clinicians. ¹⁰¹	b. Oblique c. Lateral flexion films may be indicated in scoliosis evaluation	b. Rarely adds clinical information & doubles radiation exposure to patient. ¹⁰⁸ Sometimes used to confirm presence of spondylolysis suspected from the AP & lateral films (also for suggestion of malignancy, fracture, etc). c. Low reliability of lateral flexion film for biomechanical assessment. ¹⁹⁸ Lateral bending films useful for scoliosis evaluation (see Scoliosis section).
	Special investigations [C]	Comanagement or specialist referral recommended even if conventional radiographs are unremarkable AND anyone of the following: 1. In presence of a potentially serious pathology as suggested by the patient history, examination and/or radiograph; 2. After failed conservative therapy (4-6 wk), 3. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 4. If clinical signs suggest instability. Presumed instability is loosely defined as >10° of angulation or 4 mm of vertebral translation on flexion and extension lateral radiographs. However, diagnostic criteria, natural history, and surgical indications remain controversial. ⁴⁴ 5. For preoperative planning; While MRI is excellent for identifying tumor, infection, and nerve compression, it can be overly sensitive with regard to degenerative disease findings and frequently displays pathology that is not responsible for the patient's symptoms. ¹⁹⁹ Negative findings (MRI/CT /NM) may be helpful. Structural variables on both MRI and discography have a weak association with back pain episodes and no association with disability or future care. ^{188,200} See Carragee and Hannibal (2004) ¹⁹⁹ and Saal (2002) ²⁰¹ for a review of diagnostic testing in chronic LBP.
Adults with complicated (ie, "red flag") LBP & indicators of contraindication to SMT (relative/absolute): Presence of the following indicator(s) should alert the clinician to possible underlying pathology. ^{38,42,44,63,99,112,114,167,185,197} N.B. Presence of a red flag alone may not necessarily indicate the need for radiology. • Patient <age 20 and >age 50, particularly with S&S suggesting systemic disease** Other authors recommend waiting 7 wk in untreated 1st episode of LBP and age over 65 as criteria for radiography ²⁰³ • Absence of expected treatment response or worsening after 4-6 wk • Significant activity restriction >4 wk • Nonmechanical pain (unrelenting pain at rest, constant or progressive S&S)	Radiographs indicated [B] PA (or AP), lateral lumbar views. Main purpose of lumbar spine radiographs is to exclude LBP caused by: malignancies (sensitivity of 0.6, specificity of 0.95-0.99); infective spondylitis (sensitivity of 0.82, specificity of 0.57); inflammatory SpA (low sensitivity for AS [0.25-0.45], but highly specific); fractures; and instability (sensitivity of 0.51-0.99, specificity of 0.68-0.99). High false-positive and false-negative rates are reported when assessing segmental instability by radiography ⁹⁹	**Risks of having a serious pathology may be higher before the age of 20 or over the age of 55. Particular attention to indicators of possible underlying pathology should be given for patients in these age categories. ^{6,114,208} The major diagnostic task is to distinguish the vast majority of uncomplicated LBP from the 5% with serious underlying diseases or neurologic impairments. ⁴⁴ Probability of encountering disease requiring specialized therapy in patients with LBP using radiographs is <0.2 in 100 and the probability of tumors or infection would be <1 in 1000. ^{43,121,185} Normal radiographs may falsely reassure clinicians as important causes of LBP are not easily identified with conventional radiographs (ie, not sufficiently sensitive) ¹¹⁶

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Table 3 (continued)

Patient presentation	Recommendations	Comments
• Suspected inflammatory—spondyloarthropathies (SpA) (0.3% of all LBP): chronic LBP and asymmetric peripheral arthritis, predominantly of the lower limbs, are the leading symptoms for SpA. Features of inflammatory back pain include significant morning stiffness (>1 h); pain duration ≥3 mo; persisting motion restriction; gradual onset ≤age 40; peripheral joint involvement; UTI, urethral discharge, iritis, skin rash. SI stress tests poorly reproducible. AS is regarded as the most severe subgroup. A new set of criteria for inflammatory back pain has been proposed which gives a sensitivity of 70% and specificity of 81% for the diagnosis of ankylosing spondylitis (AS)²⁰⁴: Individual features of inflammatory back pain (IBP) • Morning stiffness for >30 min • Improvement of back pain with exercise but not with rest • Awakening in the second half of the night due to back pain • Alternating buttock pain Presence of 2 features—positive likelihood ratio for AS is 3.7 Presence of 3 features—positive likelihood ratio for AS is 12.4 ** None of the IBP parameters alone are sufficient for a diagnosis of AS.²⁰⁵	Additional views [C] Spot AP or PA angled lumbosacral, oblique SI views Special investigations in complicated LBP [B] Even if conventional radiographs are negative:	Additional views may be considered in the presence of inflammatory spondyloarthropathy symptoms, although SI joints usually adequately demonstrated on AP lumbar spine. The modified New York criteria for AS diagnosis require the presence of radiographic sacroiliitis to classify the patient as having AS. However, plain radiographic abnormalities of the SI joints are a relatively late feature of disease.²¹³ New approaches for an earlier diagnosis of axial and peripheral SpA have been proposed recently. A combination of clinical, laboratory, and imaging parameters is usually necessary.²¹² Advanced imaging and specialist referral recommended even if conventional radiographs are unremarkable: 1. In the presence of a potentially serious pathology as suggested by the patient history, examination, and/or radiograph; 2. In the absence of clinical improvement after 4-6 wk of therapy; 3. If function does not improve or deteriorates; 4. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 5. With painful or progressive structural deformity 6. For unstable segment (spondylolisthesis or pathological process); 7. When patient has persisting S&S; 8. In complication from treatment (possible fracture, new/progressive neurologic deficit, considerable pain, or disability, etc)
• Suspected compression fracture (±4% of all LBP): Recent significant trauma (any age), Hx of repetitive stress of sufficient severity; Hx of high-risk osteoporosis; • Severe onset of pain with minor trauma in patients ≥age 50 (higher risk >age 70 with a likelihood ratio of 5.5), Hx of prolonged corticosteroids intake (>7.5 mg/d >3 mo) has a likelihood ratio of 12; structural deformity^{99,206}—a complaint of LBP in persons at risk may require both thoracic and lumbar radiographs.²⁰⁷ See <i>Osteoporotic Vertebral Collapse in the Thoracic Spine</i> section for details. • Suspected neoplasia (0.7% of all LBP): Considerable LBP starting ≥age 50, Hx of cancer/carcinoma in the last 15 y (likelihood ratio of >15), unexplained weight loss (>4.5 kg over 6 mo), failure of conservative care (4 wk). A combination of the above 4 features has a 100% sensitivity for cancer. Other features include no relief with bed rest (sensitivity of 0.90, but low specificity); ESR >50 mm/h, sciatica, systemically unwell; lymphadenopathy; dermatopathy (melanoma).^{6,99,203} Suspected infection (0.01% of all LBP): age >50, documented fever (>38.3°C/101°F) for >3 wk	a. MRI is generally the preferred investigation. b. CT may be needed for bony details. (especially multiplanar reformatted images)	MRI or CT useful in the detection of bone and soft tissue structures. The choice of study depends on the current clinical question, availability of equipment, and costs.²¹⁴ • Suspected cancer: MRI is especially useful for marrow-based lesions. Sensitivity is highest for MRI (0.83-0.93) and radionuclide scanning (0.75-0.98); specificity was highest for MRI (0.9-0.97) and radiography (0.95-0.99).⁴⁴ • Suspected infection: MRI is more accurate than radiography and bone scan (sensitivity of 0.96 & specificity of 0.92) for suspected osteomyelitis, spondylodiscitis, septic disc, paraspinal abscess, epidural abscess. • Suspected acute inflammation in sacroiliac joints and spine: Contrast-enhanced MRI is both sensitive & specific for active sacroiliitis (0.99 & >0.95).^{99,212,213} Although more sensitive

Table 3 (continued)

Patient presentation	Recommendations	Comments
and no established diagnosis despite appropriate investigation for 1 week (specificity of 98% with likelihood ratio of ± 25, but sensitivity of 50%); elevated ESR >20 mm/h; IV drug abuse; immunosuppression (HIV, transplant patients); UTI, skin infection, diabetes mellitus; alcohol abuse; vertebral tenderness with signs of underlying infection; direct implantation (nail, acupuncture); Hx of spine surgery^{208,209} • Suspected failed surgical fusion • Progressive or painful structural deformity ($<1\%$ of all LBP): scoliosis, kyphoscoliosis, transitional segments²¹⁰ & LDH • Abnormal laboratory examination and positive S&S: ESR >50 mm/h; Rh factor; HLAB27; reduced hematocrit; elevated white blood count; ALP; PSA; serum calcium for example.^{211,212}	c. NM	than conventional radiography, CT is not deemed useful to detect active joint inflammation. NM has had mixed results for both sensitivity & specificity.⁹⁹ c. NM: commonly used for detection of possible destructive osseous lesions, skeletal metastatic diseases (known primary tumor-skeletal survey), spinal infection, stress fracture of the pars interarticularis and acute inflammatory sacroiliitis. Bone scan, such as gallium-67 may detect spondylodiscitis as early as 48 h after inoculation.^{6,209,215} Abnormal laboratory examination: R/O marrow-based malignancies, including metastasis & primary marrow-based pathology (e.g. myeloma); serum gammopathy and possible infection & arthritis
• Suspected cauda equina syndrome (CES) (0.04% of all LBP) The classic syndrome includes LBP, bilateral or unilateral sciatica, saddle anesthesia, motor weakness of the lower extremities that may progress to paraplegia, urinary retention, or bowel and bladder incontinence. The most consistent finding of a CES is urinary retention (sensitivity of 0.90, specificity of 0.95, likelihood ratio of 18). Unilateral or bilateral sciatica, sensory and motor deficits, and abnormal SLR are common, all have a sensitivity of >0.80. The most common sensory deficit occurs over the buttocks, posterior-superior thighs, and perineal regions (saddle anesthesia), with a sensitivity of ≈ 0.75. The saddle anesthesia is characterized by altered sensation in the distribution of sacral dermatomes (S2-S5). Anal sphincter tone is diminished in 60%-80% of cases. Anal wink reflex is absent in the majority of cases.^{44,99,112,167,182,215-219}	Emergency referral without imaging If clinical findings are equivocal, medical referral and specialized imaging recommended [B] Special investigations [C] (see previous page for details)	It is vital to recognize the S&S of CES as this is a surgical emergency. Although several etiologies can cause CES (spinal tumors, epidural abscess, etc), it usually arises from a massive midline posterior disc herniation (represents 1%-2% of all operated LDH). Narrowing of the spinal canal (congenital or degenerative stenosis) is a likely predisposition to CES. To facilitate the early detection of rare but serious complications associated with disc herniations, inquiry should also be made regularly during visits with regard to saddle anesthesia or any changes in bladder or bowel functions which may suggest the development of cauda equina syndrome. The risk of SMT causing a clinically worsened disc herniation or CES in a patient presenting with an LDH has been estimated to be <1 in 3.7 million manipulations, but others have proposed figures as low as 1 in 100 million SMT. The association in some reported cases has been described as temporal rather than causal.^{44,149,161,182,220-223}
• Suspected abdominal aortic aneurysm (AAA) Uncommon before age 50, AAA prevalence increases with age (3% in <65 yoa & $>8\%$ in >65). About 25% mimic musculoskeletal LBP pain and 75% may be silent (incidental findings on physical examination and/or radiography) until rupture or size draws attention. Early S&S may include abdominal pain, back-ache, and feeling of fullness or abdominal pulsation. Patient characteristics which may raise clinical suspicion of AAA include older age,	Referral or special investigations [B] In nondissecting AAAs, medical referral and US recommended even if conventional radiographs are negative (calcification, the most reliable radiological sign, is seen in only 50% of AAA)^{229,235}	Recommendation for AAAs (symptomatic or not): Rate of growth of small AAAs is relatively predictable.²³⁶ The sensitivity of ultrasound (US) scanning for AAA is 95%, and the specificity approaches 100%; the examination is safe and reliable.²³³ Management^{42,226,227,230-233,236-240} • Ultrasound screening: Recommended in males 65 to 75 yoa (up to 80 in some studies); in females 60 to 85 yoa with cardiovascular risk factors; and in males and females >50 with a first-degree relative with AAA.

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Table 3 (continued)

Patient presentation	Recommendations	Comments
obese males, smokers or with a significant Hx of smoking, Hx of myocardial infarction, claudication, having a first relative with AAA, and presence of hypertension.²²⁴⁻²²⁷ Physical exam including abdominal inspection, auscultation, percussion, & palpation; and peripheral vascular exam. However, clinical exam cannot be relied upon to exclude AAA, especially in smaller AAAs & if abdominal girth >100 cm.^{226,228} Atherosclerosis accounts for 90%-95% of AAA, with the remainder predominantly the inflammatory type. AAAs may be defined as a permanent focal dilation of 1.5 times its normal diameter or an expansion of the aorta measuring >3.8 cm on the lateral view measured between the most distant calcified borders, usually between the renal artery (L2) and the iliac bifurcation (L4). Common iliac arteries are often involved.²²⁹ Risk factors^{225,230-234}: 1. <i>Abdominal aortic aneurysms (AAA)</i>: Male sex, cigarette smoking, a first-degree relative with AAA, hypercholesterolemia, and connective-tissue diseases (eg, Marfan, Ehlers-Danlos). 2. <i>Aneurysm expansion risk factors</i>: Advanced age (>70 y), cardiac/renal transplant, previous stroke, severe cardiac disease, tobacco use. 3. <i>Risk factors for aneurysm rupture</i>: Increases with age (age >60) and aneurysm size (diameter >5.5cm); current smoking and high mean blood pressure.		• Ultrasound monitoring: Yearly screening recommended if AAA between 3.0 and 4.4 cm (possibly every 6 mo if AAA is between 4.0 and 4.4 cm). • Referral to a vascular specialist: Recommended if AAA >4.4 cm (measures based on US or CT). ○ Annual rupture rate of small AAA (<4.5 cm) is 1%-3%. • Surgical intervention: Recommended if AAA ≥5.5 cm or growth of >0.6 cm to 0.8 cm/y. ○ Annual rupture rate and death from AAA >5.5 cm is 16%, compared with perioperative mortality of 2%-6% (or lower) for open repair.²³¹ • SMT: Relative risk of high velocity, low amplitude (HVLA) lumbar spine manipulation currently undetermined.¹⁹¹ However, considering current recommendations on AAA management, it appears reasonable to propose the following with regard to SMT: ○ Small AAA (3.8-4.0 cm): may be regarded as <i>relative</i> contraindication for SMT. Consider expansion risk factors and the need for yearly ultrasound monitoring. ○ AAA between 4.0 and 4.5 cm: consider the need for ultrasound monitoring every 6 mo. May be regarded as <i>absolute</i> contraindication for SMT in the presence of expansion/rupture risk factors. ○ Larger AAAs (≥ 4.5 cm) may be regarded as <i>absolute</i> contraindication for SMT. Refer patient to a vascular specialist. As many as 1 in 3 AAAs eventually rupture if left untreated. Most AAA deaths occur in men 65 yoa and older. Rupture of AAA is associated with a risk of death approaching 80%.^{226,233,236} AAAs confer a risk of spontaneous rupture and death, which is related to the diameter of the aneurysm: a risk of rupture of 0.5%, 1%, 11%, and 26% per year has been associated with a diameter of <4 cm, 4.0-4.9 cm, 5.0-5.9 cm, 6.0-6.9 cm, respectively.²³⁰
• Truncal symptoms attributed to presence or worsening of aortic aneurysms including dissection/rupture/occlusion or traumatic aortic injury: Cardiovascular shock and/or syncope, severe, tearing/ripping midabdominal sensation, back, groin, or testicular pain; pressure upon lumbar spine causing excruciating boring pain in the abdomen or back; hypotension; absence of distal lower limb pulses.^{224-226,241,242} At least 25% of AAAs >5 cm will rupture <i>within 5 y</i>, and those <5 cm have a rupture rate of about 5%.²²⁹	Emergency referral without imaging [GPP] <i>It is vital to recognize the S&S of dissecting AAA as this is a surgical emergency.</i>	Evaluation of acute aortic conditions including dissection/rupture/occlusion or traumatic aortic injury^{224,243}: • Because of its speed and proximity to emergency department, CT, helical CT, and CTA are imaging of choice to determine the presence and size of the aneurysms, as well as to R/O a ruptured AAA in a clinically stable patient. • MRI with MRA also plays an important role, particularly when patient is unable to receive intravenous contrast medium. • Conventional angiography is used as a secondary diagnostic tool to clarify equivocal findings. • US is helpful when CT is not readily available or patient is too unstable to undergo MRI

Table 4. *Nontraumatic thoracic spine disorders*

Patient presentation	Recommendations	Comments
Adult patient with uncomplicated* acute (<4 wk duration) thoracic spine pain^{6,38,42,63} AND Adult patient with uncomplicated* subacute (4-12 wk duration) or persistent (>12 wk duration) thoracic spine pain and no previous treatment trial.^{6,38,42,63} * Uncomplicated definition: nontraumatic thoracic pain without neurologic deficits or indicators of potentially serious pathologies—(see red flag list for details). History and physical examination should exclude causes of thoracic referred pain from nonmusculoskeletal origin (see nontraumatic chest wall pain).	Radiographs not routinely indicated [B] Special investigations not indicated [B]	Degenerative changes are generally present in the middle-age adult. Radiographs are rarely useful in the absence of neurologic signs or red flags. However, consider osteoporotic vertebral collapse or other forms of destructive bone processes in the presence of acute sudden onset pain, especially in the elderly.^{6,42,63}
Adult patient: reevaluation in the absence of expected treatment response or worsening after 4 wk.^{38,42} Should patient fail to improve as expected or marginally improve within 4 wk of initial evaluation, the clinician must review history and physical findings and request appropriate diagnostic imaging studies.	Radiographs indicated [B] AP, lateral thoracic spine views Additional views: Swimmer's view Special investigations [C] • Consider NM if conventional radiographs are unremarkable.	Symptoms located in cervicothoracic junction or if this area is not well visualized on lateral view. Comanagement or specialist referral recommended • MRI or CT scan should be considered: 1. In suspected pathology as seen on conventional radiography 2. After failed conservative therapy (4 wk), 3. If neurologic status is deteriorating (progressive deficit, disabling leg pain); Negative findings (MRI/CT/NM) may be reassuring to patients.
Adult patient with nontraumatic chest wall pain. History and physical exam first need to rule out life-threatening conditions including pathologies of the heart, lungs, and large vessels.	Emergency referral without imaging in life-threatening conditions [GPP] Special investigations [C]	Nonmusculoskeletal causes of chest wall pain include disorders of the myocardium and pericardium (infarction, angina pectoris, myocarditis, rheumatic carditis, & pericarditis) of the pleura and lung (pleurisy, empyema, pneumothorax, pulmonary infarction, pneumonia, and neoplasm), disorders of the central structures (mediastinitis, sternal thyroiditis, Hodgkin's disease, oesophagitis, hiatal hernia, aortic aneurysms with or without dissection), intra-abdominal (hepatobiliary), retroperitoneal disorders (pyelonephritis and tumors), and skin disorders such as herpes zoster.²⁴⁴ • CT and MRI²⁴⁵
Musculoskeletal chest wall pain Musculoskeletal causes of chest wall pain are a diagnosis of exclusion. Causes are generally identified upon physical examination by reproducing patient complaint (observe for skin lesions, limited and painful movements, positive orthopedic tests such as Schepelmann's sign, and tenderness on palpation).²³	Radiographs not routinely indicated [D]	Musculoskeletal causes include disorders of the rib, cartilage, and sternum (spondyloarthropathy, costovertebral syndrome, osteochondritis, Tietze's syndrome, slipping rib syndrome); muscles (intercostals, diaphragm, serratus anterior, and pectoral); and intercostal neuralgia.^{244,246-248}
Adult patient with complicated (i.e., "red flag") thoracic pain & indicators of contraindication to SMT (relative/absolute): Presence of any of the following indicators should alert the clinician to possible underlying pathology.^{8,38,44,63,112,114,167,185,197,203} N.B. Presence of a red flag alone may not necessarily indicate the need for radiography. • Patient <age 20 and >age 50, particularly with S&S suggesting systemic disease**	Radiographs indicated [B] AP, lateral thoracic spine views. Main purpose of thoracic spine radiograph is to exclude back pain caused by inflammatory spondyloarthropathy, fracture, malignancy, and infection.	Normal radiographs may falsely reassure clinicians as important causes of back pain are not easily identified with conventional radiographs (ie, not sensitive).⁷⁷

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Table 4 (continued)

Patient presentation	Recommendations	Comments
- No response to care after 4 wk. - Significant activity restriction >4 wk - Non mechanical pain (unrelenting pain at rest, constant or progressive S&S) - Persistent localized pain (>4 wk) - Progressive or painful structural deformity: scoliosis, kyphoscoliosis²¹⁰ - Symptoms associated with neurologic signs in the lower extremities	Additional views: Spot views. In suspected inflammatory spondyloarthropathy, consider spot angulated AP or PA lumbosacral or oblique SI views. Special investigations [B] * Even if conventional radiographs are negative: MRI is generally the preferred investigation. CT may be needed for bony details. NM commonly used for detection of possible destructive osseous lesions, metastatic diseases, infection, or inflammatory processes^{6,215}	Additional views may be considered in the presence of inflammatory spondyloarthropathy symptoms, although SI joints usually adequately demonstrated on AP/PA lumbar spine. Advanced imaging and specialist referral recommended even if conventional radiographs are unremarkable: - In the presence of a potentially serious pathology as suggested by the history, examination, and/or radiographs; - In the absence of clinical improvement after 4 wk of therapy; - Function does not improve or deteriorates; - If neurologic status is deteriorating (progressive deficit, disabling pain); - Painful or progressive structural deformity; unstable segment (scoliosis, kyphoscoliosis, pathological process); - Patient has persisting S&S; - Complication from treatment (possible fracture, new/progressive neurologic deficit, considerable pain or disability, etc)
Suspected inflammatory spondyloarthropathy: significant morning stiffness (>1 h); pain duration ≥ 3 mo; persisting motion restriction; gradual onset $\leq$ age 40; peripheral joint involvement; UTI, urethral discharge, iritis, skin rash.		
Suspected neoplasia: considerable pain starting $\geq$ age 50; Hx of cancer/carcinoma (in the last 15 y) and/or unexplained weight loss (>10 lb over 4 wk); or failure of conservative care (4 wk); systemically unwell; lymphadenopathy; dermatopathy (melanoma).^{6,203}		
Suspected infection: documented fever ($>38.3^{\circ}\text{C}/101^{\circ}\text{F}$) for >3 wk and no established diagnosis despite appropriate investigation for 1 week; elevated ESR >20 mm/h; IV drug abuse; immunosuppression (HIV, transplant patients); UTI, skin infection, diabetes mellitus; alcohol abuse; vertebral tenderness with underlying infection; direct implantation (nail, acupuncture); Hx of spine surgery.^{208,209}	- MRI or CT - NM - MRI especially for marrow-based lesion and neurologic disorders. MRI (Gadolinium) may increase specificity and detect spondylodiscitis as early as 48 h after inoculation²⁰⁹	- MRI or CT: Suspected primary bone tumor - NM: Known primary tumor, skeletal metastases, inflammatory arthritis, or spinal infection - MRI: More accurate than radiography and bone scan (sensitivity of 0.96 & specificity of 0.92) for suspected osteomyelitis, spondylodiscitis, septic disc, paraspinal abscess, epidural abscess; in suspected myelopathy/long tract signs, spinal cord tumors, inflammation, infection, infarction, etc
Suspected failed surgical fusion		
Abnormal laboratory examination and positive S&S: ESR >50 mm/h; RA factor; HLA-B27; BCB; ALP; PSA; serum calcium, for example.^{211,212}		Abnormal laboratory examination: R/O marrow-based malignancies, including metastasis & primary marrow-based pathology (e.g. myeloma); serum gammopathy and possible infection & arthritis
Suspected acute thoracic aortic aneurysms dissection/rupture/occlusion or traumatic aortic injury: Severe, tearing/ripping chest sensation, back pain; hypotension; absent distal pulse. High index of suspicion in connective tissue disorders and diseases with genetic predisposition for ascending aortic aneurysms such as Marfan or Ehlers-Danlos syndrome.^{249,250}	Emergency referral without imaging [GPP]	
In recent significant trauma (any age)	See Blunt Trauma/Acute Injuries section.	
Suspected compression fracture ($\pm 4\%$ of all back pain)⁶³: specific pathologies and severe trauma account for only 3% and 14%, respectively, of all clinically evident vertebral fractures. The majority in North America are related to osteoporosis. - S&S: Severe onset of pain (with or without appearance of spinal deformity) after trauma in older patients. Patients with thoracic or lumbar spine osteoporotic fractures report pain mainly in the lumbosacro-gluteal area. Look for Hx of repetitive stress of sufficient severity or Hx of high-risk osteoporosis.^{107,251} - Prevalence of asymptomatic vertebral fracture significantly increases with age and glucocorticoid use in postmenopausal women.²⁵²	Radiographs indicated [B] AP, lateral thoracic Additional views [D] Supine cross-table lateral view in suspected osteoporotic vertebral pseudoarthrosis (VPA)²⁷⁵	Although compression fractures can be visualized on conventional radiography, a clear definition for identification of these vertebral "deformities" is still lacking (absence of a true gold standard).²⁵³ Furthermore, radiography may be insensitive for revealing osteoporotic fractures^{254,276,277} and there is no consistent relationship between back pain and changes in vertebral shape on radiographs.²⁵³ Vertebral compression fractures represent a serious public health problem by virtue of the associated disability and cost. Physical function, such as cooking meals, shopping, bending, lifting, and descending stairs, self-esteem, body image, and mood are negatively affected by vertebral fractures.²⁵³

Table 4 (continued)

Patient presentation	Recommendations	Comments
- Only about one third of all affected women in the community have the severe vertebral deformities most likely to produce chronic symptoms including height loss, kyphosis and postural changes, and persistent pain interfering with daily activities.²⁵³ Risk factors for additional vertebral fractures²⁵³: - History of a previous fracture (4-fold among postmenopausal white women); - Greater age; - Lower femoral neck bone mass density (BMD); - Shorter height.		Age-adjusted incidence rates for clinically evident vertebral fractures in women are twice those in men, partly due to their greater liability to falls.²¹⁷ Lifetime risk of clinically evident osteoporotic fracture among postmenopausal North American white women >age 50 has been estimated at 40% (vertebrae 15.5%; wrist 16%; hip 17.5%)^{254,278} and at 22% in men.²⁷⁹ The incidence of osteoporotic fractures is increasing and the spectrum of fractures is changing. Fractures of the proximal femur, proximal humerus, pelvic, and many fractures around the knee should also be considered osteoporotic fractures.²⁸⁰
	Special investigations [D]	Vertebral pseudarthrosis, a rare posttraumatic vertebral delayed collapse resulting in bone ischemia, may cause vertebral instability: look for an intravertebral cleft containing gas. These patients tend to have ongoing back pain despite conservative care, severe pain during motion.²⁷⁵
Suspected osteoporosis Osteoporosis predisposing risk factors^{42,206,252,254-265}: Include nonmodifiable (age, sex, and period of amenorrhea as in anorexia nervosa and female athlete) and modifiable factors (dietary calcium intake, low BMI, smoking, inactivity, parental Hx of fracture, and high alcohol intake). See Appendix C(4) for a list of other important risk factors.	Radiographs are <i>unreliable</i> for assessment of bone mass changes before at least a 30%-50% loss.²²⁹ [B]	In suspected fracture: - Consider MRI or CT if initial radiographs are positive for fracture, equivocal, in the presence of complex lesions, for suspected ligamentous instability or neural injuries. Small fractures can also go undetected on CT scans.²⁸¹ - NM or MRI may be used to determine if fracture is recent or not, as it may impact on treatment. (NM has a 72-hour delay in elderly patients.)⁶³
Osteoporosis clinical decision rules: Several highly sensitive clinical decision rules based on weighted indices and major osteoporosis risk factors have been developed to identify women with low bone mineral density in need of DXA.^{260,266-271} - In healthy peri- and early postmenopausal women (45-64 yoa), consider using the OST score (Osteoporosis Self Assessment Tool). OST score considers only 2 variables: (weight in kg - age)/5. <i>The cut-off for a positive test is <2, indicating this woman should be referred for DXA.</i> - In higher-risk patients, use either the ORAI (Osteoporosis Risk Assessment Instrument), the more complex calculation of SCORE (Simple Calculation of Osteoporosis by Estimation) or the AMMED as all 3 were found to be highly sensitive clinical tools. See Appendix C(4) for details. - ORAI considers age, weight and estrogen use; - SCORE considers 6 variables (race, presence of RA, history of fracture, age, estrogen, weight [in pounds]); - AMMED considers 5 variables (age, years after menopause, age at menarche, BMI).	Special investigations [B] If clinical decision rules are positive	There is a concern that spinal manipulation (HVLA)^{282,283} and spinal mobilization^{281,284} could cause fractures in individuals with osteoporosis. Spinal manipulation is generally regarded as a relative contraindication in osteoporotic patients.^{239,285-287} However, in vitro studies and some case reports suggest forces generated in some manual techniques may be lower than the load required for vertebral failure (fracture) in this population.^{273,281} A number of control strategies are available that allow treatment to be applied safely and effectively.²⁸⁸ When DXA results are unavailable, use clinical decision rules to estimate the presence of osteoporosis. See Appendix C(4) for details. In suspected osteoporosis - Bone densitometry or dual-energy x-ray absorptiometry (DXA) recommended in the presence of osteoporotic fractures or with positive osteoporosis clinical decision rules (elevated risk of osteoporosis). DXA is considered the gold standard for bone mass evaluation in the diagnosis and treatment of osteoporosis (DXA >2.5 SD). In postmenopausal females, each SD decrease in lumbar spine BMD increases the risk of any fractures by 1.5-fold and of new vertebral fracture by 2.3-fold. Lateral DXA also accurate for thoracic spine evaluation.^{253,284} Of interest: - Advanced atherosclerosis of the abdominal aorta is associated with lower bone mass density, accelerated bone loss, and increase risk of incident fractures at the proximal femur. Findings in the lumbar spine have been inconsistent.²⁸⁹

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Table 4 (*continued*)

Patient presentation	Recommendations	Comments
Physical examination and osteoporosis: When likelihood of significant osteoporosis is low according to clinical decision rules, examination may include asking patient to rise from a chair and to bend forward at the trunk as vertebral fracture risk associated with loading activities increases risk by about 8- and 10-fold respectively compared with upright standing.²⁷² It should be noted, however, that vertebral tolerance to PA thoracic compressive forces is much less than axial loading.²⁷³ Simple physical tests that could assist in determining ability to tolerate thoracic spine SMT would be useful. Quality of life among adults with vertebral osteoporosis may be measured using a self-administered questionnaire such as the one from the European Foundation for Osteoporosis (QUALEFFO).²⁷⁴		Physical examination: Vertebral Fracture Index (rising from a chair & bending forward) has a lower predictive value with a lower sensitivity and specificity than axial bone mineral density measured by DXA in assessing vertebral fracture risk.²⁷²
Adult patient with nonpainful and nonprogressive scoliosis The prevalence rate in healthy adults is >30% and may be as high as 68% in the elderly.²⁹⁰ Untreated adults with late-onset idiopathic scoliosis (LIS) are productive and functional at a high level at 50-year follow-up. Untreated LIS causes little physical impairment other than back pain (most only have minimal or moderate back pain) and cosmetic concerns.²⁹¹ Patients with nonpainful and nonprogressive scoliosis are unlikely to benefit from repeat evaluation.	Radiographs not routinely indicated [C]	In a skeletally mature patient, scoliosis is defined as a spinal deformity with a Cobb angle of >10° in the coronal plane.²⁹²
Adult patient with painful or progressive scoliosis Some patients with known scoliosis may present with significant disability. Back pain is the most common clinical problem presenting as a multiform mosaic of symptoms. Constant & nonspecific back pain has a poor prognosis. Other S&S: Radicular pain & claudication when standing or walking (from nerve traction or compression), neurologic deficit may include sphincter dysfunction. Curve progression needs monitoring.²⁹² <i>Clinical evaluation:</i> Look for spinal deformity, uneven shoulder heights, limb length inequality, pelvic obliquity, hip pathology, and claudication. Neurologic exam includes nerve root tension signs, motor power, sensations, deep tendon reflexes, and pathological reflexes.²⁹³⁻²⁹⁵ - Adam's forward bend test is sensitive to detect trunk asymmetry - Maximal lateral flexion into convexity to evaluate curve functional aspect. - Scoliometer (a trunk angle of 7° indicates a structural curve >20°.) <i>Spinal deformity has an important impact on the general health status of adults as measured by the Medical Outcomes Study Short-form 36 (SF-36) and the modified Scoliosis research Society Outcome instrument (SRS-22). The SRS-22 is a disease-specific instrument assessing pain, self-image, function, mental health, and satisfaction. It is a valid, reliable, and reproducible outcomes instrument for adult deformity.</i>^{296,297}	Radiographs indicated [B] Erect sectional radiographs (better detail) or standing full-length PA (14 × 36 in) and lateral sectionals PA films* significantly reduce breast and thyroid dose. Effective doses to the digestive and respiratory systems are comparable, but are higher in the bone marrow compared to AP views.^{299,300} Full spine radiographs not recommended for patients with an AP measurement >28 cm or for older patients due to poor film quality. Consider using sectional radiographic views instead.²²⁹ Additional views: a. Right and left lateral bending	Full spine radiograph for scoliosis to determine other areas of implication a. Cobb angle b. Nash-Moe method (pedicle rotation) NB. Consider ± 5° measurement error Clinically relevant radiographic parameters in adult scoliosis including lateral vertebral listhesis, L3 and L4 endplate obliquity angles, increased lumbar lordosis and thoracolumbar kyphosis significantly correlated with pain,³⁰¹ sagittal imbalance & significant coronal imbalance of >4 cm,³⁰² lateral spondylolisthesis (lateral translation & vertebral rotation) may cause radicular pain syndrome.³⁰³ Types of lumbar scoliosis may be classified according to the lordosis and L3 obliquity. Self-reported pain & disability may increase with increasing scoliosis type (from I to III).³⁰⁴ a. Most commonly used to determine fusion levels. May help differentiate between structural and nonstructural curves and help assess primary from secondary scoliotic curves. Adult degenerative scoliosis: pathomechanism includes a viscous cycle of asymmetric degeneration (disc & facet joints) leading to asymmetric loading, leading to asymmetric deformity which in turn triggers asymmetric degeneration and loading and enhancing curve progression.²⁹²

Table 4 (continued)

Patient presentation	Recommendations	Comments
There are many causes of spinal deformity in the adult. They may be grouped as follows: (1) Primary degenerative scoliosis (mostly lumbar or thoracolumbar—triggered by disc degeneration). ²⁹⁸ (2) Progressive idiopathic adolescent scoliosis of the thoracic, thoracolumbar, and/or lumbar spine. (3) Secondary degenerative scoliosis (3a) Scoliosis after idiopathic, neuromuscular, or congenital scoliosis, or occurring in the context of pelvis obliquity, leg length discrepancy, hip pathology, or a lumbosacral transitional anomaly. (3b) Deformity secondary to metabolic bone disease (mostly osteoporosis) combined with asymmetric arthritis and/or vertebral fractures. ²⁹²	Follow-up evaluation [C] Repeat radiographs [B] Special investigations [C]	Follow-up evaluation dictated by clinical progression. Long-term follow-up of <i>adolescent idiopathic scoliosis</i> has revealed little curve progression even 20 y after bracing (7.9°) or surgical treatment (3.5°). Degenerative disc changes are more common in both patient groups compared to a control group. ³⁰⁵ Repeat radiographs, advanced imaging, and specialist referral recommended ²⁹² 1. In the absence of clinical improvement; after 4 to 6 wk of therapy; 2. If function does not improve or deteriorates; 3. In the presence of persisting S&S or considerable pain; 4. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 5. With painful or progressive structural deformity (scoliosis, kyphoscoliosis); 6. With suspected segmental instability (this is common in adult scoliosis and should be considered with all manual therapy intervention). 7. With suspected pathological process; 8. With new or progressive neurologic deficit including claudication, significant radiculopathy, or suspected syrinx; 9. To plan surgical intervention. • Spiral CT useful in rapid reconstruction of the spine. • MRI to evaluate the spinal cord and nerves. • Sequential discograms, facet blocks, epidural blocks

Table 5. *Nontraumatic cervical spine disorders*

Patient presentation	Comments
General background information Most neck pain is not the result of serious disease. Factors associated with neck pain include³⁰⁶: • Headache • Low back pain • Poor psychological health • History of whiplash injury • Poorer general or self-rated health • Possibly cigarette smoking • In patients presenting with head and/or neck pain, the physical examination should flow as a natural extension of the information obtained from the chief complaint, history, and system review. (see Honet and Ellenberg³⁰⁷ for a review of history & physical examination for neck pain). • In complaints of neck and arm pain, peripheral (weakness, dermatomal pattern, and loss of deep tendon reflexes) and central nervous system exam (clonus, Babinski, and pathological reflexes) should be an integral part of initial examination. Findings of long tract signs mandate further evaluation.	Standards of care dictate that careful history and physical examination be done routinely for all patients on the initial visit. • Self-reported patient assessment to evaluate perceived pain, function, disability, and psychosocial status are recommended. • The validity and utility of the clinical assessment (history and examination) in patients with neck pain with out radiculopathy or red flags needs to be confirmed. • Diagnostic tests such as X-rays, CT or MRI scans are only required in a minority of cases when a thorough physical examination and patient history indicate further investigation is needed. Routine imaging is unlikely to increase understanding of causation. Duration of complaint: • Acute neck pain: <4 wks' duration • Subacute neck pain: 4-12 wks' duration • Persistent/chronic neck pain: >12 wks' duration Neck pain affects nearly two third (66.7%) of the adult population over their lifetime representing a significant and costly health problem in terms of care, suffering, and work absenteeism.³¹⁵⁻³¹⁷ Contrary to prior belief, most individuals with neck pain do not experience complete resolution of their symptoms and disability. The age-standardized 6-month point prevalence is around 22% with nearly 40% having low-intensity and low-disability neck pain, 10% having high-intensity and low-disability neck pain and 4.6% (95% CI, 3.3-5.8) having disabling pain.³¹⁶

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Table 5 (continued)

Patient presentation		Comments
• In headache complaints, vital signs (to R/O severe hypertension or fever) and testing of the cranial nerves (to R/O vascular events, space occupying lesions, etc) should be an integral part of initial examination. Significant positive findings mandate further evaluation. • In suspected connective tissue disorders, examination should also include inspection of the integument (skin elasticity, discoloration), the back (scoliosis), the thorax (deformity, abnormal respiratory pattern), and extremities (disproportion), auscultation of the heart (valvular defect) and abdominal aorta (bruit), abdominal palpation (organomegaly in fibromuscular dysplasia-kidney, aorta), and musculoskeletal examination including peripheral joint laxity using the 1998 Beighton criteria and examination of chronic joint and limb complaints.³⁰⁸ Auscultation of the neck and the use of common premanipulation vascular screening tests (eg, Houles, George, etc) are of no diagnostic value. Functional vascular tests may themselves put patient at risk of a serious complication.³⁰⁸⁻³¹⁴		The age and sex annual incidence of neck pain is 14.6% (95% CI, 11.3-17.9) and each year, 0.6% develop disabling neck pain. Annual course of neck pain is as follows: 36.3% resolve and 32.7% improve. Among neck pain sufferers, 33.3% report persistent problems, 9.9% get worst, and 22.8% recur.³¹⁷ Between 22% and 25% of initial chiropractic visits are for neck-related complaints. Although most patients seeking chiropractic care experienced their symptoms for <3 wk (45%), over 20% had symptoms for >6 mo.⁴¹ In addition, 5%-6% of chiropractic patients consult for headache. Neck pain is slightly more common in females and increases with age, the mean age being in the early 40s.^{41,100} Not surprisingly, these figures parallel the most common age range seeking consultation for chiropractic spinal manipulative therapy (61% of females; mean age of 42 years old).
Adult patient with acute uncomplicated* neck pain (<4 wks' duration)	Radiographs not routinely indicated [C]	The clinical value of conventional radiographs for nontraumatic acute neck pain <i>without</i> red flags or arm pain is not well established. Acute neck pain is generally due to conditions that cannot be seen on conventional radiographs.^{38,42,128} The clinical significance of the cervical spine curvature remains controversial.^{138,155,319-323} Consider cervical radiography, advanced imaging studies, and a second opinion in the absence of expected treatment response or worsening after 4 wk.^{38,42}
* Definition of "uncomplicated": nontraumatic neck pain without underlying neurologic deficits or red flag (see red flags list for details).^{42,63,318}	Special investigations not indicated [C]	
Adult patient with nontraumatic neck pain and radicular symptoms May be caused by HNP, spondylosis, and rarely by other pathological processes (tumor, abscess, etc). ³¹⁸	Radiographs indicated [D/consensus] APOM, AP lower cervical, neutral lateral	Disc lesions cannot be visualized on radiographs. IVF narrowing by facet & uncinat process hypertrophy are very often associated with radicular symptoms.³³⁴⁻³³⁶ Spinal stenosis (sagittal diameter <13 mm) may also be present, in which case special care should be taken if manual therapy is considered. Always examine the patient's lower extremities for upper motor neuron signs indicating cervical radiculo-myelopathy (Hoffman sign, lower limb hyper-reflexia, spasticity, Babinski, and/or Clonus).^{307,335,336} Clinical diagnosis of CDH possible in only 50%-75% of cases of cervical radiculopathy as a wide variation of presentations exists even with only one nerve root involved (C6 more common than C7 which is more common than C8 level). Patients should be monitored as S&S may progress in the first 2-3 wk.^{38,337} When applied by properly trained and experienced practitioners, SMT is potentially a safe treatment option for patients with <i>nonprogressive</i> cervical radiculopathy secondary to CDH and LCS.³³⁸⁻³⁴⁰ Premanipulative position test may help determine whether patient can tolerate cervical manipulative procedure. Technique adaptation/mobilization recommended in patients with acute cervicobrachial pain.²³⁹ a. MRI provides more useful information than conventional radiography oblique views. Oblique views may be considered in cervical radiculopathy, spondylotic myelopathy, and extensive degenerative, apophyseal joints, pedicles.^{229,341}
(A) Suspected acute cervical disc herniation (CDH) ^{42,307,324-333} :		
• 35-55 yoa		
(B) Suspected acute cervical spondylotic radicular syndrome/lateral canal stenosis (LCS) ^{307,330,331} :		
• 45-54 yoa		
Common S&S of acute cervicobrachial syndrome (A and B) ^{38,307,330-333} :		
• Predominant arm & scapular pain with or without neurologic deficit: Specific weakness and/or hypoesthesia and/or hyporeflexia. • Provocation tests (Spurling's, axial compression) & possible nerve root tension signs (upper limb tension test, median nerve & medial cord stretch test, shoulder depression, brachial-plexus compression, or arm pain relieved by cervical traction and/or Bakody).		
• Possible increased intra-theal pressure (Valsalva/Dejerine triad)	Additional views: a. Oblique views	
N.B. Consider past imaging studies for evidence of disc pathology and/or moderate to advanced cervical spondylosis.		

Table 5 (continued)

Patient presentation		Comments
When consistent with the history and other physical findings, a positive Spurling's, traction/neck distraction, and Valsalva's might be indicative of a cervical radiculopathy, whereas a negative upper limb tension test (contralateral neck rotation and extension of the arms and fingers) might be used to rule out radiculopathy. ³³³	b. Swimmer's view	b. Consider swimmer's view if symptoms located in cervicothoracic (C/T) junction or if this area is not well visualized on lateral view.
See Appendix C(5) for a detailed list of clinical criteria for cervicobrachial syndrome.	Special investigations [C] Combined with radicular symptoms, specific findings on examination (manual provocation tests), and possibly needle EMG findings, MRI may be helpful in confirming the site and level of root compression.	Comanagement or specialist referral or MRI recommended even if conventional radiographs are unremarkable ^{38,42,63} 1. After failed conservative therapy (4 wk); 2. Major neurological deficits at onset, disabling radicular pain or progression of deficits; 3. For preoperative planning
1. Adult patient with uncomplicated* subacute neck pain (4-12 wks' duration) with or without arm pain³¹⁸ * Definition of "uncomplicated": nontraumatic neck pain without underlying neurologic deficits or red flags (see red flag list below for details). AND 2. Adult patient with persistent neck pain (>12 wk) with or without arm pain^{63,318} Psychological distress/depressive mood, somatization, perceived disability, and passive coping behavior are important predictors of chronicity and poor outcome in persistent neck pain.^{202,342} An important association exists between a Hx of a WAD, pain intensity, & disability and co-morbidity (headache, LBP, digestive, & cardiovascular disorders).⁸⁶⁻⁸⁸ Complete history should therefore include a system review.	Radiographs not initially indicated [Consensus] APOM, AP lower cervical, neutral lateral NB. This recommendation was modified according to the recent findings of The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and it's Associated Disorders (see articles published in Spine 2008; 33(4S). A majority of Delphi panelists agreed with this change (92% of 50 respondents). Additional views: a. Oblique views b. Swimmer's view c. Flexion/extension	Vertebral degeneration and anterior slippage (anterolisthesis) increases with age. However, there appears to be no correlation between neck pain (with or without prior trauma) and the severity or the number of levels of disc, facet or uncovertebral joint degeneration, or degree of anterior slippage, but for the exception of a weak association between chronic neck pain (>6 month) & the severity of the degenerative disc disease (when present in the lower cervical spine).^{42,320,343-347} a. Oblique views may be considered in cervical radiculopathy, spondylotic myelopathy, and extensive degenerative disease to evaluate IVFs, uncovertebral joints, apophyseal joints, pedicles.²¹⁸ However, MRI provides more useful information than conventional radiography oblique views. b. Consider swimmer's view if symptoms located in cervicothoracic (C/T) junction or if this area is not well visualized on lateral view. c. Flexion/extension views are indicated in suspected segmental instability: high-risk ligament laxity populations (Down's, RA and other inflammatory spondylo-arthropathies), failed surgical fusion, trauma and advanced degenerative disc disease.^{6,348} Patients should be supervised during procedure. An ADI interval >3 mm is abnormal.³⁴⁹
Adult patient reevaluation in the absence of expected treatment response or worsening after 4 wk^{60,318} See Appendix C(6) for a list of psychological risk factors (yellow flags) and clinical indicators of significant anxiety or depression in whiplash patients.	Radiography indicated [C] APOM, AP lower cervical, neutral lateral Special investigations [B] (1. subacute neck pain, 2. persistent neck pain, and 3. reevaluation in absence of treatment response or worsening after 4 weeks)	Comanagement or specialist referral or MRI recommended even if conventional radiographs are unremarkable.^{38,42,63} 1. If conventional radiography reveals suspected pathology; 2. After failed conservative therapy (4 wk); 3. If patient neurologic status is deteriorating (progressive deficit, disabling arm pain); 4. If clinical signs suggest subaxial cervical spine instability; 5. For preoperative planning; NB. The frequency of all degenerative MRI findings increases linearly with age with disc degeneration being the most frequent ranging from 12% in asymptomatic males & females in their 20s to 89% in those over age 60. Posterior disc protrusion and even slight cord compression are not rare in asymptomatic subjects over age 40 with reduction of the cross-sectional area of the spinal cord not exceeding 16%.³⁵⁰⁻³⁵²

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Table 5 (continued)

Patient presentation	Radiographs indicated [B]	Comments
Adult patient with complicated (ie, “red flag”) neck pain & indicators of contraindication to SMT Presence of the following indicator (s) should alert the clinician to possible underlying pathology^{38,42,63,308,318,353-363}: NB. Presence of a red flag alone may not necessarily indicate the need for radiography. • Patient <age 20 and >age 50, particularly with S&S suggesting systemic disease** • No response to care after 4 wk. • Significant activity restriction >4 wk • Nonmechanical pain (unrelenting pain at rest, constant or progressive S&S) • Neck rigidity in the sagittal plain in the absence of trauma (discitis, infection, tumor, meningitis, etc); • Dysphasia; • Impaired consciousness; • Central nervous system S&S (cranial nerves, pathological reflexes, long tract signs); • High risk ligament laxity populations/suspected atlantoaxial instability (see details below); • Arm or leg pain with neck movements; • Suspected cervical myelopathy and radiculo-myelopathy (see details below); • Sudden onset of acute and unusual neck pain and/or headache (typically occipital) with or without neurologic symptoms, suspected cervical artery dissection (VAD, CAD), TIA (VBI, carotid artery ischemia), stroke (see details below); • Hx of severe trauma (see Trauma section). In addition, also consider general red flags (relative utility and cost-effective of screening patients for non traumatic neck pain for serious structural disease (“Red Flags”) need to validate) which may apply to the cervical spine • Suspected neoplasia: considerable pain starting ≥age 50; Hx of cancer/carcinoma (in the last 15 y) or failure of conservative care (4 wk), lymphadenopathy; dermatopathy (melanoma). S&S of cervical spine tumors tend to be variable (slight pain, neck stiffness, scoliosis, presence of a mass and/or severe neurologic deficit). Night pain remains a classic indicator of nonmechanical neck pain and neoplasm. Other systemic symptoms may include unexplained weight loss (>10 lb over 4 wks) and systemically unwell.^{6,38,355,356} • Suspected infection (discitis, osteomyelitis, tuberculosis): documented fever (>38.3°C/101°F) for >3 wk and no established diagnosis despite appropriate investigation for 1 week; elevated ESR >20 mm/h; IV drug abuse; immunosuppression (HIV, transplant patients); UTI, skin infection, diabetes mellitus; alcohol abuse; vertebral tenderness with underlying infection; direct implantation (nail, acupuncture); Hx of spine surgery.^{208,209} • Suspected failed surgical fusion; • Progressive or painful structural deformity;	APOM, AP lower cervical, neutral lateral Additional views: a. Flexion/extension b. Oblique views c. Pillar Special investigations^{6,38,42,63} [B]	Normal radiographs may falsely reassure clinicians as important causes of neck pain are not easily identified with conventional radiographs (i.e., not sensitive) APOM useful for trauma, inflammatory arthropathy, high-risk atlantoaxial instability populations, malignancy, known congenital anomaly. ** Risk of having a serious pathology may be higher before age 20 & over age 55. Particular attention to indicators of possible underlying pathology should be given for patients in these age categories. a. Flexion/extension views indicated in suspected segmental instability: high-risk ligament laxity populations (Down’s, RA, and other inflammatory spondylo-arthropathies), failed surgical fusion, trauma, and advanced degenerative disc disease.^{6,348} Patients should be supervised during procedure. An ADI interval >3 mm is abnormal.³⁴⁹ b. Oblique views may be considered in suspected fracture, malignancy, and other equivocal findings on standard AP and lateral radiographs (radiculopathy, spondylotic myelopathy, and extensive degenerative disease). c. Pillar views may be considered in severe trauma (CT usually done instead—see Trauma section) Advanced imaging and specialist referral recommended: • MRI for suspected myelopathy (tumors, inflammation, infection, infarction, etc). In cases of atlantoaxial instability, MRI (F/E) shows effects on cord compression when radiograph is positive or neurologic signs are present.

Table 5 (continued)

Patient presentation	Comments
• Abnormal laboratory examination and positive S&S: ESR >50 mm/h; RA factor; HLA-B27; BCB; ALP; PSA; serum calcium, for example.^{211,212} Note: It may be reasonable to consider many of the lumbar spine red flags in complaints of neck pain. However, their level of evidence as such is currently unknown.¹⁵⁵	Abnormal laboratory examination: R/O marrow-based malignancies, including metastasis & primary marrow-based pathology (eg, myeloma); serum gammopathy and possible infection & arthritides
1. Suspected atlantoaxial instability (AAI): High-risk ligament laxity populations/possible atlantoaxial instability include^{6,63,229,357-363}: (a) Active inflammatory arthritis: known rheumatoid arthritis (RA), psoriatic arthropathy, chronic juvenile RA, and less commonly in AS (2% of cases). S&S of presumed inflammatory spondyloarthropathy include significant morning stiffness (>1 h); pain duration ≥3 mo; persisting motion restriction; gradual onset ≤age 40; peripheral joint involvement; UTI, urethral discharge, iritis, skin rash.³⁶⁴ (b) Congenital disorders & hereditary connective tissues disorders such as dysplasia, os odontoideum, Klippel-Feil, Morquios, Down's syndrome (20% are born without a transverse ligament), Ehlers-Danlos syndrome type III, Marfan syndromes. Screening for high-risk ligament laxity populations is important for manual therapists. Little is known about the value of commonly used manual tests. Although agreement and reliability between 2 examiners is difficult to achieve for general cervical spine mobility & intersegmental passive mobility,³⁶⁵ acceptable levels of predictive value, sensitivity, and specificity have been reported for the Sharp-Purser test.³²⁰ Cattryse et al³⁶⁶ were not able to reproduce such results in a small group of children with Down's syndrome, however. Preliminary data support the use of the upper cervical flexion test for those patients.	Radiographs indicated [B] APOM, AP lower cervical, neutral lateral Additional views [D] a. Flexion/extension laterals*⁶ * Flexion/extension views indicated in suspected AAS. However, a single lateral cervical radiograph with the patient in supervised comfortable <i>flexion</i> should reveal any subluxation in patients with rheumatoid arthritis, Down's syndrome, etc.⁶ Special investigations [C] Monitoring, advanced imaging and specialist referral recommended^{63,318,348,369,371,372}: - ADI >3 mm, vertical dislocation, lateral, posterior, or subaxial subluxations - Upward odontoid translocation (pseudobasilar invagination) - In the presence of neurologic S&S ◆ CT and MRI provide detailed images of the bone and spinal cord lesions.
2. Suspected cervical compressive myelopathy (CCM) and radiculo-myelopathy Causes of cord compression include trauma, tumors, infection, vascular disease, degenerative conditions, demyelinating disorders, spinal stenosis, & central cervical disc herniation. <i>Cervical spondylotic myelopathy (CSM)</i>^{63,372-375} - MC >50 y; - Variable neurologic deficit of upper (hyporeflexia) and lower extremities (hyperreflexia); axial skeleton sensory and motor dysfunction that skip the head & face; - Arm or leg pain with neck movements; - Long tract signs and pathological reflexes (Clonus, Babinski, Hoffman); Lhermitte's sign (cervical flexion and extension producing electrical shocks down the arm and leg); - Subtle gait abnormality (loss of balance, spasticity, unsteadiness, loss of leg power, broad base, shuffle and disruption in smooth, rhythmic function);	Radiographs indicated [C] APOM, AP lower cervical, neutral lateral, and bilateral oblique views. Additional views: Swimmer's view For cervical spondylotic myelopathy, patients should be treated conservatively if they have a spinal transverse area >70 mm², are of older age, and have normal central motor conduction time. Surgery is more suitable for patients with clinically worse status (function expressed as modified Japanese Orthopaedic Association score and slower walk) and a smaller transverse area of spinal cord.³⁷⁶ Central spinal stenosis, acute cervical myelopathy, and/or radiculo-myelopathy is generally considered a contraindication for manual therapy although some patients with nonacute & nonprogressive S&S have safely received such intervention. Caution is advised in those patients as even minor trauma in patients with preexisting severe spondylosis has potentially serious consequences.^{318,336,339,340,377-385} Consider Swimmer's view if symptoms are located in cervicothoracic junction or if this area is not well visualized on lateral view. a. A sagittal diameter <13 mm indicates spinal stenosis and is critical for the development of a cervical

(continued on next page)

Table 5 (*continued*)

Patient presentation		Comments
6. Bowel & bladder dysfunction (rare). Neurologic examination in patients with CSM is moderately accurate and reliable for determining the neurologic level of disease. Among the neurologic tests (deep tendon reflex, pinprick response, muscle weakness, and numbness in the hand only), patient-perceived location of numbness in the hands may be the most useful for establishing the affected level.³⁷⁴		radiculo-myelopathy, even in the presence of mild degenerative spondylosis (normal is 17-18 mm between C3-C7). Caution is recommended if AP diameter <11 mm and manual therapy is contemplated.³¹⁸ b. A Torg' or Pavlov ratio (spinal canal/vertebral body) <0.8 indicates spinal stenosis.^{334,383,386} NB. It is important to recognize that conventional radiography may not be very reliable to determine central canal stenosis as there is some variation in the size of the spinal cord and stenosis may be due to nonosseous factors (ligamentum flava, cartilage hypertrophy etc).
3. Suspected cervical artery dissection (VAD, CAD), TIA (VBI, carotid artery ischemia), stroke. In most cases, there is little that could prospectively alert even the astute practitioner to an impending vascular event. Most patients are young, apparently healthy individuals, suffering from musculoskeletal complaints without any predisposing stroke risk factors. The most important points in the history and chief complaint, which would warn of a possible cervical artery disease, are^{308,318,354,387,388}: a. S&S of VBI—the “5D’s and 3 N’s”: dizziness, dysphasia, dysarthria (hoarseness), drop attacks, diplopia (or other visual problems), ataxia of gait (hemiparesis), nausea (possibly with vomiting), numbness (hemianesthesia), nystagmus. b. S&S of carotid artery ischemia/stenosis: confusion, dysphasia, headache, anterior neck and/or facial pain, hemianesthesia, hemiparesis or monoparesis, visual field disturbances. c. Neck or occipital pain with sharp quality and severe intensity <i>or</i> severe & persistent headache that is sudden and unlike any previous experienced pain or headache (even when it is suspected the pain is of a musculoskeletal or neuralgic origin)	Emergency referral without imaging [GPP] Urgent referral should be made for appropriate investigation and treatment in patient presenting S&S of cerebrovascular ischemia or when S&S of head/neck pain is suspicious for an acute cervical artery disease. Initial investigation often includes CT scan of the brain to R/O hemorrhagic stroke.	If patient reports active/existing VAD, CAD, TIA/stroke, DO NOT proceed with cervical manipulation Emergency care: <i>It is vital to recognize the S&S of cerebrovascular ischemia and stroke in which case patient must be referred immediately to emergency facility for early and appropriate treatment.</i> Additional information: a. Sudden onset of acute and unusual headache and/or neck pain is present in 92% of cases of cervical artery dissection and may occur either spontaneously, after a specific activity, a significant neck trauma, or after cervical spine manipulation. b. Immediate or delayed neurologic S&S developing spontaneously, after a specific activity, a significant neck trauma, or after cervical manipulation; including the 5 D’s and 3 N’s are absolute contraindications to SMT. c. S&S of internal carotid artery dissection: most common presentation: headache and neck pain (90%), ischemic symptoms (50%-95%), Horner’s syndrome (<52%), visual scintillation (33%), monocular blindness (6%-30%), subjective bruit (25%-48%), impairment of taste (10%-19%).⁴⁰²
Any reports consistent with TIAs, prior stroke history (1% risk of recurrence/year), severe hypertension (noted in half of cases of spontaneous/idiopathic vertebral artery dissection), Hx of a major cervical spine trauma (attributed to 10% of vertebrobasilar syndrome), cardiac abnormalities that predispose to thrombus formation or myolytic arteriopathy should prompt close observation for neurologic status.^{308,318,389,390}	Special investigations [C] Appropriate consultation and/or diagnostic procedures to evaluate the status of the cerebral circulation required in patients presenting with significant risk factors for cervical artery dissection. In such cases, approach the treatment with caution until a specific determination is made.^{308,318}	Should cervical artery problems be suspected, a thorough workup is indicated which may include²⁴⁵: • Gold standard diagnostic tests (MRI/MRA) should be performed before implementing any manipulative procedure.³⁰⁸ • US imaging of the cervical vessels is typically used as a fast, noninvasive screen when pathology is suspected. Color-coded duplex ultrasonography can help diagnose vertebral artery (VA) occlusion and VBI by measuring blood flow velocity & flow volume and diameter of the VAs (including hypoplasia & asymmetry).^{354,403-406} However, US is operator dependant, lacks resolution, and has some limitations associated with vertebral artery evaluation. For these reasons, ultrasound may not be a viable screening tool.^{407,408}

Table 5 (*continued*)

Patient presentation	Comments
Although several risk factors have been proposed for cervical artery dissection,^{308,318,387-399} current literature <i>does not assist</i> in identification of precipitating causes. VBIs may be considered the result of cumulative events over time/multifactorial.^{400,401} The patient history should include a system review and family history.	• Catheter digital angiography is an invasive procedure with associated risk of stroke ($\approx 1\%$). MRI/MRA considered method of choice as initial diagnosis and follow-up of craniocervical artery dissection. See Mullins⁴⁰⁹ and Foerster et al²⁴⁵ or a review on stroke imaging
Further consideration	Further considerations 1. External structures such as facet & uncovertebral joint osteophytes and presence of a retroarticular canal may potentially compress the vertebral artery.⁴¹⁰⁻⁴¹² However, no cases were found to be associated with either retroarticular canal or posterior ponticle in young adults.³⁰⁸ Although 1 case of VBI and one stroke have been associated with vertebral artery stenosis from osteophytes, cervical spondylosis does not appear to increase the risk of vertebrobasilar accidents after vertebral manipulation. If such were the case, one would expect older patients (>45 yoa) to be at heightened risk, but they are not.³⁸⁸⁻³⁹⁰ There is currently no evidence that in the absence of red flags in the adult patient, routine cervical spine radiographs before initiating manipulative therapy have any value as a mean to reduce rare, random, unpredictable vascular complications associated with neck movement, trivial trauma, or cervical manipulation.^{308,318,390} 2. Limiting neck rotation during SMT and applying the smallest force required to achieve therapeutic objective is advisable.^{311,413} 3. Migraine headache is a risk factor for stroke in young patients. When possible, treat all stroke modifiable risk factors aggressively, especially in women over age 35: smoking, oral contraceptives, presence of aura, >12 attacks of migraines/year, >12 y of migraine history.⁴¹⁴ 4. Tests and imaging studies that would help screen patients at risk of adverse vascular events before receiving cervical SMT would be of great help. However, such studies are not available presently.³⁰⁸ There is currently no evidence that in the absence of red flags, routine cervical spine radiographs before initiating manipulative therapy have any value as a means to reduce rare, random, unpredictable vascular complications associated with neck movement, trivial trauma, or cervical manipulation. 5. In patients with past a history of <i>major trauma to the cervical spine*</i>, MRA or angiography recommended before treating the neck as follow-up MRA indicates that these damaged vertebral arteries usually do not recanalize.⁴¹⁵⁻⁴²¹ In a review of 80 cases of traumatic vertebral ischemia, MVA were thought to be responsible for 77.5% of cases, with delays between trauma and the onset of neurologic S&S of up to 5 y. The severity of trauma caused loss of consciousness (LOC) in 70% either at the time of injury or with subsequent episode of vertebrobasilar ischemia and short-term memory deficit in 64%. However, severity of trauma was mild for many, with no LOC, and no blow to the head.⁴²²

ARE THERE POTENTIAL RISKS ASSOCIATED WITH CONVENTIONAL RADIOGRAPHS?

Although somewhat controversial,²⁰⁻²³ it is important to remember that health hazards of all forms of radiation are cumulative.²³⁻³⁰ The Biological Effects of Ionizing Radiation (BEIR) 2005 report released by the National Academy of Sciences adds further support to the “linear-no-threshold” model of cancer risk from ionizing radiation exposure.³¹ In summary, this report concludes that ionizing radiation is dangerous even at low doses and that there are no safe limits. Given the potential risks associated with conventional radiographs, only appropriate clinical indications can justify its use. In this regard, the need to confirm pathology, to follow the evolution of a pathology possibly affecting therapy, or to identify a clinically suspected contraindication to manipulative therapy is the best-documented reason. The benefits of all diagnostic studies must outweigh the risks and the inherent costs to the patient.^{10,32-40}

Tables 1-5 list the patient presentations, recommendations, and comments regarding diagnostic imaging for spine disorders. A list of abbreviations and glossary of terms used in the recommendations is in Appendix A. Appendix B provides a summary of the recommendations. Pertinent information for spinal disorders is presented in Appendix C. General indications for advanced imaging are in Appendix D. Typical effective ionized radiation dose for common imaging procedures is listed in Appendix E. Further recommended reading pertaining to magnetic resonance imaging of the spine is offered in Appendix F.

Practical Applications

- History taking and physical examination to exclude underlying sinister cause (red flags) and serious injuries (fracture and/or dislocation)
- Physical examination for signs of nerve compression
- Diagnostic triage (non specific back, neck, and extremity pain, with or without restriction of activity of daily living, radicular syndrome, presence of red flags)
- Radiographs not initially indicated for non specific acute, subacute, or persistent back and neck pain (no red flags)
- Consider conventional radiography after blunt trauma (according to decision rules), and if there is no improvement after 4-6 weeks of conservative care or increasing disability
- Consider conventional radiography and specialized imaging for radicular syndrome and presence of red flags
- Urgent specialized imaging for back and neck pain with adverse features: sphincter or gait disturbance, saddle anesthesia, severe or progressive neurologic deficit, systemic illness (cancer, infection), vascular causes (suspected abdominal/thoracic aorta aneurysm), or cervical artery dissection.

ACKNOWLEDGMENT

We appreciate the efforts of the many people who assisted in this process, listed in Appendix G.

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jmpt.2007.10.003 and in tables D1-D3 in Appendix D of Reference 2.

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APPENDIX A. LIST OF ABBREVIATIONS AND GLOSSARY FOR SPINE DISORDERS

AAA:	Abdominal aortic aneurysms
AAS:	Atlantoaxial subluxation
ACR:	American College of Radiology
ALP:	Alkaline phosphatase (if elevated, R/O cancer, infection Paget’s disease)
AP:	Anteroposterior
APOM:	Anteroposterior open mouth
AS:	Ankylosing spondylitis
BMI:	Body mass index
CES:	Cauda equina syndrome
CNS:	Central nervous system
CAD:	Cervical artery dissection
CI:	Confidence interval
CT:	Computed tomography (advanced imaging modality that uses ionizing radiation [Table 1]. Generally considered to be the gold standard imaging for the chest, abdomen, pelvis, complex osseous anatomy, or in musculoskeletal disorders when contraindications for MRI exist).

CTA:	Computed tomography angiography
DDx:	Differential diagnosis
Dx:	Diagnosis
ESR:	Erythrocyte sedimentation rate (if elevated, R/O inflammation due to cancer, infection, fracture)
GHQ-28:	General Health Questionnaire
GPP:	Good Practice Point
HNP:	Herniated nucleus pulposus/disc herniation
Hx:	History
IVF:	Intervertebral foramen
JRA:	Juvenile rheumatoid arthritis
LBP:	Low back pain
LDH:	Lumbar disc herniation
LOE:	Level of evidence
MC:	More common
Mo:	Month
MRA:	Magnetic resonance angiography—gadolinium enhanced
MRI:	Magnetic resonance imaging (generally considered to be the best single advanced imaging modality of the spine to confirm or exclude most clinically relevant findings after conventional radiographs)
NM:	Nuclear medicine (also known as bone scan or scintigraphy) uses a radiopharmaceutical and gamma camera to produce a physiologic skeletal survey (Table 1). Has high sensitivity but low specificity.
NDI:	Neck Disability Index
PA:	Posteroanterior
PSA:	Prostate-specific antigen (R/O prostate cancer)
Red Flag:	Indicator of potentially serious pathology obtained from history, physical examination, and/or radiographs. Nonspecific/uncomplicated/mechanical neck and back pain are considered diagnoses of exclusion. Patients should therefore be properly evaluated for indicators of potentially serious pathology before undergoing some forms of manual therapy.
RA:	Rheumatoid arthritis
Rh factor:	Rheumatoid factor (indicates possible rheumatoid arthritis; 2%-5% false positive)
ROM:	Range of motion
R/O:	Rule out
SLR:	Straight leg raise test
SMT:	Spinal manipulative therapy—high-velocity, low-amplitude thrust techniques
S&S:	Signs and symptoms
TIA:	Transient ischemic attack
Tx:	Treatment
US:	Ultrasound
VAD:	Vertebral artery dissection
VBA:	Vertebrobasilar accident
VBI:	Vertebrobasilar insufficiency
WAD:	whiplash associated disorder
W/O:	Without
X-ray:	Conventional radiograph
yoa:	Years of age
<:	Less than
>:	Greater than
≥:	Equal to or greater than
Ψ:	psychology/psychiatry

APPENDIX B. SUMMARY OF RECOMMENDATIONS

Table 1. *Summary of Recommendations—Thoracolumbar, Lumbar, and Thoracic Spine Trauma*

Patient Presentation	Recommendations
Adult patient with recent (<2 wk) acute thoracolumbar, lumbar, or thoracic spine trauma Absence of pain, normal ROM, and absence of neurologic deficits	Radiographs not routinely indicated [C]
Adult patient with thoracolumbar, lumbar or thoracic spine blunt trauma or acute injuries (falls, MVAs, motorcycle, pedestrian, cyclists, etc)	Radiographs indicated [B] Lumbar <i>AND</i> thoracic spine: AP, lateral views
High-risk screening criteria for spinal injuries include any of the following: 1. Back pain 2. Midline tenderness on palpation 3. Distracting painful injury and other high-risk mechanism of injury* 4. Neurologic deficits 5. Altered consciousness (caused by head trauma, intoxication/ethanol, or drugs)	Special investigations [C] • CT scan (multidetector [multislice], spiral CT) • MRI
Adult patient with posttraumatic chest wall pain	
Minor trauma	Radiographs not routinely indicated [D]
Major trauma	Radiographs indicated [GPP] PA, lateral chest radiographs, Specific rib radiographs (AP, oblique)
	Additional views: PA chest in full expiration, Thoracic and /or lumbar spine views
	Special investigations [GPP] • CT for sternum injury, pulmonary, pleural, and osseous abnormalities
Adult patient with pelvis and sacrum trauma (including falls with inability to bear weight)	Radiographs indicated [D] AP Pelvis and lateral hip "frog leg"
	Additional views: lateral lumbar view, Angulated AP sacrum view (15-45° cephalad)
	Special investigations [D] • NM, MRI or CT may be helpful if radiographs are normal or equivocal.
Coccyx trauma and coccydynia Consider views of the sacrum if distal <i>sacrum fracture is suspected</i>	Radiographs not routinely indicated: (spot AP, lateral coccyx) [C]
	Additional views: AP, lateral sacrum, Dynamic sitting lateral views of the coccyx

Table 2. *Summary of Recommendations—Cervical Spine Trauma*

Patient Presentation	Recommendations
Adult patient with acute neck injury and <i>negative</i> CCSR (Canadian Cervical Spine Rule for Radiography in Alert and Stable Trauma Patients)	Radiographs not routinely indicated [B]
Adult patient with acute neck injury and <i>positive</i> CCSR (Canadian Cervical Spine Rule for Radiography in Alert and Stable Trauma Patients)	Radiographs indicated [B] APOM, AP lower cervical, neutral lateral
Conventional radiographs recommended in the presence of any of the <i>Canadian Cervical Spine Rule</i> criteria are fulfilled: (A) <i>High-risk factors in alert and stable patient?</i> 1. Age >65 2. Dangerous mechanisms of injury* 3. Paresthesias in extremities (B) <i>Low-risk factors that allow ROM assessment?</i> 1. Simple rear end collision** 2. Patient seated in the waiting room 3. Ambulatory at one time since trauma 4. Delayed cervical pain onset 5. Absence of midline cervical tenderness (C) <i>ROM assessment:</i> is patient able to <i>actively</i> turn his/her head to 45� in both directions?	If fracture is suspected: 3 views + CT scan recommended Additional views: CT now replaces oblique, pillar, dynamic flexion/extension (F/E) in suspected fracture [GPP] Special investigations [C] • CT, MRI

Table 3. *Summary of Recommendations—Adult Nontraumatic Lumbar Spine Disorders*

Patient Presentation	Recommendations
Adult patient with acute uncomplicated* LBP (<4 wks' duration)	Radiographs not initially indicated [B]
* <i>Uncomplicated definition:</i> nontraumatic LBP without neurologic deficits or indicators of potentially serious pathologies—(see red flag list for details). For most young or middle-aged adults, early diagnostic evaluation of low back complaints may focus on 3 basic questions: diagnostic imaging is infrequently required (Jarvik 2002). ⁴ 1. Is there underlying systemic disease? 2. Is there neurologic impairment that might require surgical intervention? 3. Is social or psychological distress amplifying or prolonging the pain?	Special investigations not indicated [B]
Adult patient with uncomplicated subacute (4-12 wks' duration) or persistent LBP (>12 wks' duration) AND no previous treatment trial. A trial of up to 4-6 wk of conservative care is appropriate before radiographs	Radiographs not initially indicated [B]
Adult patient with nontraumatic acute LBP AND sciatica (no red flags) The first clinical clue to neurologic impairment usually is a history of sciatica: sharp pain radiating down the posterior or lateral aspect of the leg, often associated with numbness or paresthesia.	Radiographs not initially indicated [B]

Table 3 (continued)

Patient Presentation	Recommendations
Specific Clinical Diagnoses:	
Common causes of sciatica	
(A) Suspected LDH: • Risk factors for LDH include: men (1.6 times more likely), middle age (35-54 y), repetitive/heavy lifting, current smoking, obesity (high BMI), and type of occupation. • Predominantly leg pain, typically involving the foot	Radiographs not initially indicated [B] unless patient age >50 or has progressive neurologic deficits
(B) Suspected degenerative spondylolithesis/lateral stenosis • Back pain with or without leg pain • Increased pain with activity • S&S with or without neurologic deficit	Radiographs indicated if patient age >50 or has progressive neurologic deficits: PA (or AP), lateral lumbar views [GPP]
(C) Suspected lumbar degenerative spinal stenosis • MC >65 yoa (sensitivity of 0.7; specificity of 0.69) • Neurogenic claudication • Variable neurologic deficit (numbness, weakness, etc)	Radiographs indicated if patient age >50 or has progressive neurologic deficits: PA (or AP), lateral lumbar views [C]
Suspected causes of sciatica: (A) Lumbar disc herniation (B) Degenerative spondylolithesis/lateral stenosis (C) Lumbar degenerative spinal stenosis	Special investigations not initially indicated [C] Co-management or specialist referral recommended even if conventional radiographs are unremarkable: 1. After failed conservative therapy (4-6 wk) 2. For preoperative planning; 3. If patient's neurologic status is deteriorating (progressive deficit, disabling leg pain); • MRI, CT
Adult patient reevaluation in the absence of expected treatment response or worsening after 4-6 wk Should patient fail to improve as expected or marginally improve within 4-6 wk of initial evaluation, the clinician must review history and physical findings and request appropriate diagnostic imaging studies.	Radiographs indicated [B] PA (or AP), lateral lumbar views Additional views not routinely indicated [C] Spot lateral, oblique. lateral flexion films may be indicated in scoliosis evaluation Comanagement or specialist referral recommended even if conventional radiographs are unremarkable 1. And if conventional radiography reveals suspected pathology. 2. After failed conservative therapy (4-6 wk), 3. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 4. If clinical signs suggest instability. Presumed instability is loosely defined as >10° of angulation or 4 mm of vertebral displacement on flexion and extension lateral radiographs. However, diagnostic criteria, natural history, and surgical indications remain controversial 5. For preoperative planning; Special investigations [C] • MRI or CT scan
Adults with complicated (ie, "red flag") LBP and indicators of contraindication to SMT (relative/absolute): Presence of the following indicator(s) should alert the clinician to possible underlying pathology. Presence of a red flag alone may not necessarily indicate the need for radiology. • Patient <age 20 and >age 50, particularly with S&S suggesting systemic disease**	Radiographs indicated [B] PA (or AP), lateral lumbar views. Additional views: Hibb's, (Spot angled PA or AP lumbosacral), oblique SI views

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Table 3 (continued)

Patient Presentation	Recommendations
• <i>No response to care after 4 wk</i> • <i>Significant activity restriction >4 wk</i> • <i>Nonmechanical pain (unrelenting pain at rest, constant or progressive S&S)</i> • <i>Suspected inflammatory—spondyloarthritides</i> • <i>Suspected compression fracture</i> • <i>Suspected neoplasia</i> • <i>Suspected infection</i> • <i>Suspected failed surgical fusion</i> • <i>Progressive or painful structural deformity</i> • <i>Elevated laboratory examination and positive S&S</i>	Advanced imaging and specialist referral recommended: 1. In the presence of a potentially serious pathology as suggested by the patient history, examination, and/or radiograph; 2. In the absence of clinical improvement after 4-6 wk of therapy; 3. If function does not improve or deteriorates; 4. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 5. With painful or progressive structural deformity 6. For unstable segment (spondylolisthesis or pathological process); 7. When patient has persisting S&S; 8. In complication from treatment (possible fracture, new/progressive neurologic deficit, considerable pain, or disability, etc) Special investigations [B] Even if conventional radiographs are negative • MRI, CT, NM
• <i>Suspected CES</i> The classic syndrome includes LBP, bilateral or unilateral sciatica, saddle anesthesia, motor weakness of the lower extremities that may progress to paraplegia, urinary retention, or bowel and bladder incontinence.	Emergency referral without imaging [B] Special investigations [C] (see above for details)
• <i>Suspected AAA</i> Early S&S may include abdominal pain, backache, and feeling of fullness or abdominal pulsation.	Referral for specialized investigations [B] • Management (ultrasound screening/monitoring and surgical consultation) according to patient history and size of AAA
• <i>Truncal symptoms attributed to the presence or worsening of aortic aneurysms including dissection/rupture/occlusion or traumatic aortic injury</i> Cardiovascular shock and/or syncope, severe, tearing/ripping midabdominal sensation, back, groin or testicular pain; pressure upon lumbar spine causing excruciating boring pain in the abdomen or back; hypotension; absence distal lower limb pulses	Emergency referral without imaging [GPP] • It is vital to recognize the S&S of dissecting AAA as this is a surgical emergency.

Table 4. Summary of Recommendations—Nontraumatic Thoracic Spine Disorders

Patient Presentation	Recommendations
Adult patient with uncomplicated* acute thoracic spine pain (<4 wks' duration) <i>AND</i> Adult patient with uncomplicated* subacute (4-12 wks' duration) or persistent (>12 wks' duration) thoracic spine pain and no previous treatment trial. <i>* Uncomplicated definition:</i> nontraumatic thoracic pain without neurologic deficits or indicators of potentially serious pathologies	Radiographs not routinely indicated [B] Special investigations not indicated [B]
Adult patient: reevaluation in the absence of expected treatment response or worsening after 4 wk. Should patient fail to improve as expected or marginally improve within 4 wk of initial evaluation, the clinician must review history and physical findings and request appropriate diagnostic imaging studies.	Radiographs indicated [B] AP, lateral thoracic spine views Additional views: swimmer's view Co-management or specialist referral recommended 1. In suspected pathology as seen on conventional radiography 2. After failed conservative therapy (4 wk), 3. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); Special investigations [C] • MRI or CT scan

Table 4 (continued)

Patient Presentation	Recommendations
Adult patient with nontraumatic chest wall pain History and physical exam first need to rule out life-threatening conditions including pathologies of the heart, lungs and large vessels.	Emergency referral without imaging in life-threatening conditions [GPP] Special investigations [C] • CT and MRI
Musculoskeletal causes of chest wall pain (diagnosis of exclusion).	Radiographs not routinely indicated [D]
Adult patient with complicated (ie, “red flag”) thoracic pain and indicators of contraindication to SMT (relative/absolute) Presence of the following indicator(s) should alert the clinician to possible underlying pathology. NB. Presence of a red flag alone may not necessarily indicate the need for radiography. Patient <age 20 and >age 50, particularly with S&S suggesting systemic disease** • No response to care after 4 wk. • Significant activity restriction >4 wk • Nonmechanical pain (unrelenting pain at rest, constant or progressive S&S) • Persistent localized pain (>4 wk) • Progressive or painful structural deformity: scoliosis, kyphoscoliosis (Otani 2001) • Symptoms associated with neurologic signs in the lower extremities • Suspected inflammatory spondyloarthropathy • Suspected neoplasia • Suspected infection • Suspect failed surgical fusion • Elevated laboratory examination and positive S&S • In recent significant trauma (any age)	Radiographs indicated [B] AP, lateral thoracic spine views. Additional views: spot view. In suspected inflammatory spondyloarthropathy, consider: Hibb’s (spot angled AP lumbosacral), oblique SI views Advanced imaging and specialist referral recommended even if conventional radiographs are unremarkable: 1. In presence of a potentially serious pathology as suggested by the patient history, examination and/or radiograph; 2. In the absence of clinical improvement after 4 to 6 wk of therapy; 3. If function does not improve or deteriorates; 4. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 5. With painful or progressive structural deformity 6. For unstable segment (spondylolisthesis or pathological process); 7. When patient has persisting S&S; 8. In complication from treatment (possible fracture, new/progressive neurologic deficit, considerable pain or disability, etc) Special investigations [B] • MRI, CT, NM
• Suspected acute thoracic aortic aneurysms dissection/rupture/occlusion or traumatic aortic injury Severe, tearing/ripping chest sensation, back pain; hypotension; absent distal pulse. High index of suspicion in connective tissue disorders and diseases with genetic predisposition for ascending aortic aneurysms.	Emergency referral without imaging [GPP]
• Suspected compression fracture Severe onset of pain (with or without appearance of spinal deformity) after minor trauma in older patients. Patients with thoracic or lumbar spine osteoporotic fractures report pain mainly in the lumbosacro-gluteal area. Look for Hx of repetitive stress of sufficient severity or Hx of high risk osteoporosis Risk factors for additional vertebral fractures: Histories of a previous fracture, greater age, lower femoral neck bone mass density, shorter height.	Radiographs indicated [B]: AP, lateral thoracic spine views. Additional views [D]: supine cross-table lateral view in suspected osteoporotic vertebral pseudoarthrosis Special investigations [D] • MRI/CT if initial radiographs are positive, difficult to interpret, in presence of complex lesions, for suspected ligamentous instability or neural injuries.
Suspected osteoporosis See osteoporosis clinical decision rules	Radiographs are <i>unreliable</i> for assessment of bone mass changes before at least a 30%-50% loss Special investigations [B] if clinical decision rules are positive • Bone densitometry or dual-energy x-ray absorptiometry (DXA)

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Table 4 (continued)

Patient Presentation	Recommendations
Adult patient with nonpainful and nonprogressive scoliosis	Radiographs not routinely indicated [C]
Adult patient with painful or progressive scoliosis	Radiographs indicated [B] Erect sectional radiographs (better detail) or standing full-length PA (14 × 36 in) and lateral sectionals Additional views: 1. Right and left lateral bending Follow-up evaluation dictated by clinical progression [C] Repeat radiographs, specialist referral and advanced imaging recommended [B]: 1. In the absence of clinical improvement; after 4 to 6 wk of therapy; 2. If function does not improve or deteriorates; 3. In presence of persisting S&S or considerable pain; 4. If patient neurologic status is deteriorating (progressive deficit, disabling leg pain); 5. With painful or progressive structural deformity (scoliosis, kyphoscoliosis); 6. With suspected segmental instability (this is common in adult scoliosis and should be considered with all manual therapy intervention). 7. With suspected pathological process; 8. With new or progressive neurologic deficit including claudication, significant radiculopathy or suspected syrinx; 9. To plan surgical intervention. Special investigations [C] • Spiral CT, MRI, sequential discograms, facet blocks, epidural blocks, CT-myelogram.

Table 5. Summary of Recommendations—Nontraumatic Cervical Spine Disorders

Patient Presentation	Recommendations
Adult patient with acute uncomplicated* neck pain (<i><4 wks' duration</i>) * <i>Uncomplicated definition:</i> nontraumatic neck pain without neurologic deficits or indicators of potentially serious pathologies—(see red flag list for details).	Radiographs not initially indicated [C] Special investigations not indicated [C]
Adult patient with nontraumatic neck pain and radicular symptoms (A) Suspected acute cervical disc herniation (CDH) (B) Suspected Acute cervical spondylotic radicular syndrome/lateral canal stenosis	Radiographs indicated [D/consensus] APOM, AP lower cervical, neutral lateral Additional views: oblique views, swimmer's view Comanagement or specialist referral recommended even if conventional radiographs are unremarkable 1. After failed conservative therapy (4 wk) 2. For preoperative planning; 3. If patient neurologic status is deteriorating (progressive deficit, disabling arm pain); Special investigations [B] MRI

Table 5 (continued)

Patient Presentation	Recommendations
Adult patient with uncomplicated* subacute (4-12 weeks duration) and persistent neck pain (>12 weeks) with or without arm pain.	Radiographs not initially indicated* [consensus] APOM, AP lower cervical, neutral lateral N.B. This recommendation was modified according to the recent findings of The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and it's Associated Disorders (see articles published in Spine 2008; 33(4S)). A majority of Delphi panelists agreed with this change (92% of 50 respondents).
Adult patient reevaluation in the absence of expected treatment response or worsening after 4 weeks.	Radiographs indicated [C] APOM, AP lower cervical, neutral lateral Additional views: Oblique views, Swimmer's view, Flexion/Extension Comanagement or specialist referral recommended (even if conventional radiographs are unremarkable) 1. If conventional radiography reveals suspected pathology. 2. After failed conservative therapy (4 wk), 3. If patient neurologic status is deteriorating (progressive deficit, disabling arm pain); 4. If clinical signs suggest subaxial cervical spine instability. (Moore 2006) 5. For preoperative planning; Special investigations [B] • MRI
Adult patient with complicated (ie, "red flag") neck pain and indicators of contraindication to SMT Presence of the following indicator(s) should alert the clinician to possible underlying pathology. N.B. Presence of a red flag alone may not necessarily indicate the need for radiography. • Patient <age 20 and >age 50, particularly with S&S suggesting systemic disease** • No response to care after 4 wk • Significant activity restriction >4 wk • Nonmechanical pain (unrelenting pain at rest, constant or progressive S&S) • Neck rigidity in the sagittal plain in the absence of trauma (discitis, infection, tumor, meningitis, etc); • Dysphasia; • Impaired consciousness; • Central nervous system S&S (cranial nerves, pathological reflexes, long tract signs); • High risk ligament laxity populations/suspected atlantoaxial instability(see details below); • Arm or leg pain with neck movements, suspected cervical myelopathy and radiculo-myelopathy (see details below); • Sudden onset of acute and unusual neck pain and/or headache (typically occipital) with or without neurologic symptoms, suspected cervical artery dissection (VAD, CAD), TIA (VBI, carotid artery ischemia), stroke (see details below); • Hx of severe trauma (see Trauma section).	Radiographs indicated [B] APOM, AP lower cervical, neutral lateral Additional views: flexion/extension, oblique views, pillar view Advanced imaging and specialist referral recommended: Special investigations [B] • MRI

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Table 5 (continued)

Patient Presentation	Recommendations
In addition, also consider general red flags (usually applied to LBP) which may apply to the cervical spine • <i>Suspected neoplasia</i> • <i>Suspected infection (discitis, osteomyelitis, tuberculosis)</i> • <i>Suspect failed surgical fusion</i> • <i>Progressive or painful structural deformity</i> • <i>Elevated laboratory examination and positive S&S</i>	
• Suspected atlantoaxial instability (AAI) High risk ligament laxity populations/possible atlantoaxial instability include (a) Active inflammatory arthritides (b) Congenital disorders and hereditary connective tissues disorders	Radiographs indicated [B] APOM, AP lower cervical, neutral lateral Additional views [D]: flexion/extension laterals Monitoring, advanced imaging and specialist referral recommended: 1. ADI >3 mm, vertical dislocation, lateral, posterior or subaxial subluxations 2. Upward odontoid translocation (pseudobasilar invagination) 3. In presence of neurologic S&S Special investigations [C] • CT, MRI
• Suspected cervical compressive myelopathy (CCM) and radiculo-myelopathy	Radiographs indicated [C] APOM, AP lower cervical, neutral lateral and bilateral oblique views. Additional views: swimmer's view Refer patient for investigation and possible surgical intervention: 1. After failed conservative therapy (4 wk), 2. If patient's neurologic status is deteriorating (progressive deficit, disabling arm pain); 3. For preoperative planning; Special investigations [C] • MRI (CT-myelography if not available). Electrophysiologic testing such as somatosensory evoked potentials (SSEP) may be useful.
• Suspected cervical artery dissection (VAD, CAD), TIA (VBI, carotid artery ischemia), stroke The most important points in the history and chief complaint, which would warn of a possible cervical artery disease, are: a. S&S of VBI—the “5D’s And 3 N’s”: dizziness, dysphasia, dysarthria (hoarseness), drop attacks, diplopia (or other visual problems), ataxia of gait (hemiparesis), nausea (possibly with vomiting), numbness (hemianesthesia), nystagmus; b. S&S of carotid artery ischemia/stenosis: confusion, dysphasia, headache, anterior neck and/or facial pain, hemianesthesia, hemiparesis or monoparesis, visual field disturbances. c. Neck or occipital pain with sharp quality and severe intensity or severe and persistent headache that is sudden and unlike any previous experienced pain or headache (even when it is suspected the pain is of a musculoskeletal or neuralgic origin) Should cervical artery problems be suspected, a thorough workup is indicated.	Emergency referral without imaging [GPP] Urgent referral should be made for appropriate investigation and treatment in patient presenting S&S of cerebrovascular ischemia or when S&S of head/neck pain is suspicious for an acute cervical artery disease. Special investigations [C] • Initial investigation often includes CT scan to R/O hemorrhagic stroke. Appropriate consultation and/or diagnostic procedures to evaluate the status of the cerebral circulation required in patients presenting with significant risk factors for cervical artery dissection. In such cases, approach the treatment with caution until a specific determination is made.

APPENDIX C. PERTINENT CLINICAL INFORMATION

(1) Thoracic spine trauma

The thoracolumbar injury severity scale (TLISS) may be helpful in referral decision-making process. The scale is based on the mechanism of injury, the integrity of the posterior ligamentous complex, and the neurologic status.^{i,ii} The TLISS has good reliability and compares favorably to other contemporary thoracolumbar fracture classification systems.ⁱⁱⁱ

Description	Points
1. Injury mechanism	
a. Compression	
• Simple compression	1
• Lateral angulation >15�	1
• Burst	1
b. Translation/rotational	3
c. Distraction	4
2. Posterior ligamentous complex (PLC)	
disrupted in tension, rotation, or translation	
a. Intact	0
b. Suspected/indeterminate	2
c. Injured	3
3. Neurologic status	
a. Nerve root involvement	2
b. Cord, conus medullaris involvement	
• Incomplete	3
• Complete	2
c. Cauda equina involvement	3

The score is a total of 3 components: injury mechanism, PLC integrity, and neurologic status. A score of ≤ 3 suggests nonoperative treatment (bracing); 4, operative or nonoperative treatment; and ≥ 5 suggests operative treatment.

(2) Cervical spine trauma

Risk factors for WAD may include personal, societal, and environmental factors. Both physical and psychological factors are likely to play a role in recovery or non-recovery from whiplash injury. High initial symptom severity (high initial pain level, pain-related limitations, greater number of symptoms and painful body parts), greater psychological distress and passive coping may predict poorer outcome.^{iv} Finally, an important association exists between a Hx of a whiplash associated disorder, pain intensity, and disability and comorbidity (headache, LBP, digestive, and cardiovascular disorders).^{vi,vii}

a. Adult Patient with Acute Neck Injury and Positive CCSR

Proposed whiplash associated disorders classification included Foreman and Croft (1995), the Quebec Task Force^{viii} and revised classification on Whiplash Associated Disorders.^{ix-x}

- **Grade 0:** no neck pain or sensitivity
- **Grade I:** neck pain, stiffness or tenderness only. No physical signs
- **Grade II:** neck pain, stiffness or tenderness, decreased range of motion (musculoskeletal signs). Consider psychological impairment (elevated psychological distress, high levels of posttraumatic stress), and interference with daily living.
- **Grade III:** neck complaints accompanied by neurologic signs such as decreased or absent deep tendon reflexes, weakness and/or sensory deficits. Also consider psychological impairment (elevated psychological distress, levels of posttraumatic stress), and interference with daily living.
- **Grade IV:** fractures, dislocation (or spinal cord lesions).

A biopsychosocial model may improve WAD treatment and help prevent chronic disability.^{xi}

Classification of patients with chronic WAD may include measures of self-efficacy, disability, and coping such as the NDI, Multidimensional Pain Inventory-Swedish version (MPI-S), The Self-Efficacy Scale, and the Coping Strategies Questionnaire.^{xii}

b. Cervical Spine Injury Severity Score

The Cervical Spine Injury Severity Score (CSISS), which was developed to measure stability after cervical spine trauma, has excellent intraobserver agreement (ICC, 0.97-0.99) and interobserver agreement (ICC, 0.75-0.98). This classification system is based on morphological descriptions and on quantifiable values of stability and applies to all fractures of the

subaxial spine from the caudal aspect of C2 to T1. The score is based on bony and ligamentous disruption of the 4 columns of the cervical spine (anterior, right pillar, left pillar, and posterior osseous ligamentous complex) and correlates to increasing instability. Each column is graded using an analog scale from 0 to 5. Thus, the injury severity score ranges from 0 to 20, with 0 being no injury and 20 the most severe. The CSISS does not take into account neurologic function or deficits. A morphologic description of subaxial cervical fracture is proposed.^{xxiii}

For more information on nonoperative management and treatment of spinal injuries and timing of surgical intervention in spinal cord injuries, see the reviews from Reichtine^{xiv} and Fhelings.^{xv}

(3) Clinical Criteria for the Diagnosis of LDH.^{xvi, xvii, xviii, xix}

Nerve root pain due to disc-root conflict should be deemed to be a symptom of multifactorial origin in which the neural and perineural inflammatory reactions and their mediators play a major role that is flanked by venous stasis due to mass effect on the perineural circulation. Nerve compression appears to play an adjuvant role by generating nerve conduction abnormalities due to fiber demyelination by a direct or indirect anoxic-ischemic mechanism.^{xx}

Clinical criteria for the diagnosis of LDH include sciatic pain that originates at the back or buttock and radiates below the knee, either unilaterally or bilaterally, typically involving the foot. Often, a history of recurrent LBP over several months or years, with occupational risk factors, is reported before leg pain onset. The patient often has difficulty rising from a sitting or supine position and typically experiences only partial pain relief while supine. Coughing or sneezing often exacerbates the low back and leg pain (positive Valasalva).

On physical examination, the patient is in acute distress and may manifest an antalgic posture/gait and decreased lumbar lordosis due to marked paraspinal muscle guarding. Lumbar spine ranges of motion may be restricted, especially in forward flexion. Lower extremity neurologic examination^{xxi, xxii, xxiii} may reveal diminished deep tendon reflexes, loss of motor power, and sensory deficit of the involved nerve root (L4, L5, or S1). Reduced ankle reflex (L5-S1), weakness of ankle dorsiflexion (L4-5), foot drop, or weakness of the big toe (L5) requires special attention, as does reduced light touch in the L4, L5, or S1 dermatome. Straight leg raise will typically be restricted on the involved side with a high sensitivity (0.8) but a low specificity (0.4), whereas a crossed SLR (well leg-raise test) has a low sensitivity (0.35) but a high specificity (0.9) for the diagnosis of herniated discs. This may be confirmed by nerve root tension tests such as bowstring and Braggard's.

Wasserman maneuver (Elys test) evokes pain by stimulating the L2-L4 nerve roots when hyperextending the hip with the knee flexed at 90 while the patient is prone. Examination may reveal reduced patellar reflex (L2-L4), weakness of the quadriceps (L2-4), and possibly of ankle dorsiflexion (L4-5), and/or reduced light touch in L2, L3, or L4 dermatome. Bony and soft tissue tenderness may be noted over the lumbar and gluteal region, although not a prominent feature.

(4) Thoracic Spine Osteoporosis

A woman 65 years of age with one vertebral fracture has a 1 in 4 chance of another fracture over 5 years, which can be reduced to 1 in 8 by treatment. Positive treatment decisions are often contingent on identifying a vertebral fracture.^{xxiv}

Although it may not be possible to restore normal bone structure in women with osteoporosis, antiresorptive agents (eg, bisphosphonates, selective estrogen receptor modulators) can substantially reduce the risk of new vertebral fracture, even without corresponding increase in bone mass density, by reducing excessive bone turnover. Elevated bone turnover can be assessed with a number of biochemical markers such as osteocalcin, bone-specific alkaline phosphatase, C-telopeptides of type I collagen and N-telopeptide cross-links of type I collagen.^{xxv}

a. Important Osteoporosis Risk Factors:^{xxvi, xxvii, xxviii, xxix, xxx, xxxi, xxxii, xxxiii, xxxiv, xxxv, xxxvi, xxxvii}

- a. Age ≥ 50 (higher risk >70);
- b. BMI or weight ($<19 \text{ kg/m}^2$ or $<57 \text{ kg}$);
- c. Ethnic group or race (white or Asian);
- d. Menopause before age 45;
- e. Loss height ($>4 \text{ cm}$);
- f. Hx of corticosteroid Tx for rheumatoid arthritis and other immune and inflammatory disorders ($5\text{--}7.5 \text{ mg/d} \times 3 \text{ months}$);
- g. Hx of fragility fracture after age 45 of one of the following sites: hip, rib, wrist;
- h. No Hx of hormone replacement therapy/estrogen such as premarin, estrace, estraderm, estrab;
- i. Vitamin D and vitamin K deficiency, aluminum bone disease (dialysis, TNP), hypogonadism, malabsorption syndromes; Hx of anorexia/bulimia nervosa, female athlete triad
- j. Excessive alcohol/caffeine intake; smoking, dilantin;

- k. Immobilization >4 weeks after age 45;
- l. Low birth size and poor childhood growth
- m. Elevated blood pressure;
- n. Cognitive decline.

b. Osteoporosis Risk Assessment^{xxxviii,xxxix,xi,xli,xlii,xliii,xliv}

In healthy perimenopausal and early postmenopausal women (45-64 years), consider using the Osteoporosis Self Assessment Tool (OST score): the OST considers only 2 variables: (weight in kilograms – age)/5. The cut-off for a positive test is <2, indicating this woman should be referred for DEXA.

In higher-risk patients, use either one of the following 3 clinical tools as they were all found to be highly sensitive:

1. Osteoporosis Risk Assessment Instrument (ORAI) which considers age, weight, and estrogen use (Table 1).
2. Simple Calculation of Osteoporosis by Estimation (SCORE) which considers 6 variables (race, RA, history of fracture, age, estrogen, weight (in pounds) (Table 2).
3. Age, years after menopause, age at menarche, BMI (AMMED) (Table 3).

Table 1. Osteoporosis Risk Assessment Instrument (ORAI).

ORAI variables	Points added to index
Age >75 y	15
Age 65-74 y	9
Age 55-64 y	5
Weight <60 kg	9
Weight 60-90 kg	3
Not current HRT user	2

The cut-off for a positive test is >8; indicating this woman should be referred for DEXA.

Table 2. Simple Calculation of Osteoporosis by Estimation (SCORE).

SCORE variables	Points added to index
Race	5 if NOT black
Rheumatoid arthritis	4 if has RA
History of fracture	4 for EACH type (wrist, rib, hip) of nontraumatic fractures >45 y (maximum score of 12)
Age (y)	3 times first digit of age
Estrogen	1
Weight (in lbs)	–1 times weight divided by 10 and truncated to integer

The cut-off for a positive test is >6, indicating this woman should be referred for DEXA.

Table 3. Age, Years After Menopause, Age at Menarche, BMI (AMMEB).

AMMEB Variables	Points added to index
Age (y)	15 if 75 +, 9 if 65-74, 5 if 55-64, 0 if <55
BMI	6 if <20, 2 if 20-23, 1 if 24-26, 0 if >26
Age at menarche	0 if 11, 1 if 11-13, 6 if >13
Postmenopausal period	5 if >16, 3 if 12-16, 1 if 5-11, 0 if >5.

The cut-off for a positive test is ≥ 10, indicating this woman should be referred for DEXA

(5) Clinical Criteria for the Diagnosis of Cervicobrachial Syndrome

Cervical radiculopathy is a disorder of the cervical spinal nerve root, and most commonly is caused by a CDH or other space-occupying lesion. The annual incidence of cervical spine disc herniation with radiculopathy is approximately 5.5 per 100 000 and tends to affect patients aged 35 to 55 years of age. The levels most commonly affected are C5-C6 and C6-C7.^{xlvi} A clinical diagnosis of CDH is possible in only 50% to 75% of cases of cervical radiculopathy as a wide variation of presentations exists even with only 1 nerve root.^{xlvi,xlvii} Patients should be monitored as signs and symptoms may progress in the first 2 to 3 weeks.

Historical questions with diagnostic accuracy include shoulder/scapular pain, symptoms influenced by neck movement, presence of numbness/tingling, intermittent signs and symptoms, and symptoms that interrupt sleep.^{xlvi}

On physical examination, the patient is generally in acute distress and may manifest an antalgic posture. The upper limb tension test (ULTT) appears useful as a screening test given its high sensitivity (0.97). If the ULTT is negative, then cervical radiculopathy (CR) can essentially be ruled out, and the need for further work up or treatment for CR is minimized. Findings with useful diagnostic accuracy include cervical spine ranges of motion restriction (ipsilateral rotation less than 60 , and neck flexion less than 55 ). Although not very sensitive, the following tests have moderate to high specificity for CR: traction/neck distraction, spurling, Valsalva, and the shoulder abduction test, reduced or absent dermatomal sensation (C5 most accurate), motor power, and deep tendon reflex (biceps most accurate). The probability of the condition increases with several positive findings.^{xlix,l}

(6) Persistent Neck Pain

(a) Identification of psychological risk factors (yellow flags):^{li}

- Obvious psychological distress
- Severe pain beyond what is expected
- Hx of prior significant pain recurrences
- Higher than expected functional impairment
- Unexplained widespread pain
- Pain and limitation not consistent with objective findings.

(b) Mental status indicators of significant anxiety or depression:^{li}

- Insomnia or nightmares
- Irritability
- Withdrawal
- Panic episodes or anxiety during the day or night
- Persistent tearfulness
- Poor concentration
- Inability to enjoy
- Poor appetite/weight loss
- Poor libido
- Thoughts that "life is not worth living"

Clinicians are encouraged to use validated patient self-administered questionnaires to evaluate perceived neck pain, function, disability, and psychosocial status.

(c) Suspected cervical artery dissection (VAD, CAD), TIA (vertebrobasilar ischemia, carotid artery ischemia), stroke.

Acute neck pain is generally due to musculoskeletal conditions that respond well to conservative therapy. Risks of adverse events need to be addressed when considering any form of therapy. Several risk factors have been proposed for cervical artery dissection.^{lii,liii,liv,lv} Cervical artery dissection may be considered multifactorial,^{lvi} resulting from cumulative events over a period of time. Patient having cervical artery dissections tend to be females under the age of 45: recently, an etiologic model to help explain the pathogenesis of cervical artery dissection has been proposed.^{lvii} Recent studies and reviews discussing the nature of the association between vertebrobasilar stroke and chiropractic care are available elsewhere.^{ix-xi}

It is likely that patients in the early stages of VBA stroke are presenting to a health care professional because of neck pain and headache due to pre-existing vertebral artery dissection which is a risk factor for VBA stroke.

None of the proposed risk factors may be visualized on conventional radiography. Few case reports have linked advanced cervical spondylosis to vertebral artery dissection, suggesting osteophytes off the uncovertebral joint or superior articular process may be associated to a dissection. Advanced cervical spondylosis mostly concerns the older age population which would normally undergo radiographs when presenting with a neck complaint. Major neck trauma is likely an independent risk factor for CAD. Again, imaging studies are indicated in those circumstances.

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APPENDIX D. GENERAL INDICATIONS FOR ADVANCED IMAGING IN SPINE DISORDERS

Indication	MRI	CT	CT-myelo	NM
Evaluation of primary bone neoplasm detected on radiographs	++	+	+	
Determining skeletal distribution of neoplasms or other multifocal skeletal disease				++
Clinical or laboratory tests suggesting plasma cell myeloma	++			
Posterior vertebral body scalloping seen on radiographs	++			
Known or suspected spinal cord tumors (malignant or nonmalignant), cord injury secondary to trauma, myelopathy, multiple sclerosis	++			
Myelopathy or radiculopathy when MRI is contraindicated or unavailable		+	++	
Spinal stenosis (congenital/degenerative)	+	++	+	
Cauda equine syndrome	++		+	
Persistent back or neck pain <i>with or without</i> radiculopathy and positive straight leg raise test, abnormal reflex, dermatome, or myotome with no improvement after 4 wk of conservative care	++			
Rapidly progressing neurologic deficit and/or motor weakness	++			
Infectious spondylodiscitis, osteomyelitis, tuberculosis	++	+		+
Rapidly progressing left-sided or atypical scoliosis	++			
Complicated disease processes or findings unexplained by more conservative tests	+	+		
Postoperative evaluation of arthrodesis		+		
Postoperative evaluation of recurrent symptoms (disc herniation and fibrosis)	++ GAD			
Burst fracture, pathological vertebral body compression fracture, or other unstable fractures	+	++		
Suspected occult fracture	+	+		++
Unstable or complex congenital anomalies or deformities of the spine	++	+		
Platybasia/basilar impression	++			
Enlarged sella as seen on cervical radiographs (brain) (MR imaging indicated)	++			

++ indicates first choice; +, second choice (must be determined on a case-by-case basis).^{a,b}

NB. For the estimated accuracy of imaging technique for lumbar spine conditions, please see Jarvik (2002).⁴

a. Adapted with permission from Peterson C. Canadian Guidelines for Imaging, 2002 (unpublished).

b. Taylor JAM. NYCC imaging protocols, 2003 (unpublished).

APPENDIX E. TYPICAL EFFECTIVE IONIZED RADIATION DOSE FOR COMMON IMAGING PROCEDURES*

Class	Typical effective dose (mSv)	Examples
0	0	Ultrasound, MRI
I	<1	Radiograph: cervical and thoracic spine, extremities, pelvis, and lungs
II	1-5	Lumbar spine radiograph, nuclear medicine, cervical spine CT
III	5-10	Chest and abdomen CT

* Classification of the typical effective dose of ionizing radiation from common imaging procedures. Adapted from: European Commission. Radiation Protection 118. Referral guidelines for imaging in conjunction with the UK Royal College of Radiologists; Italy 2001. p 21.

APPENDIX F. ADDITIONAL READING RECOMMENDED ON SPINAL MRI

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APPENDIX G. ACKNOWLEDGMENTS

The authors express their sincere appreciation to all Delphi panelists (phase 5), external reviewers (phases 4 and 7), and to the quality of literature assessors (phase 2): Jeffrey Cooley, Jonathon Egan, Michael Morgan, Julie O'Shaughnessy, and Jason Napuli, whose significant contributions were essential in the completion of this project. We are grateful to chiropractic college presidents for recommending faculty members for the Delphi panel. We have appreciated the feedback received by colleagues in the field during and after the worldwide consultation on the Web (Phase 6). Many thanks to Dr Andre Cardin of Universit  du Qu bec   Trois-Rivi res for his significant input in the initial draft (phase 3); Dr Michelle Wessely of the Institut Franco-Europeen de Chiropratique and Dr Julie-Marthe Grenier of Universit  du Qu bec   Trois-Rivi res for their valuable editorial input; and to Drs Carlo Ammendolia, DC, PhD; Joe Lemire DC, MSc; John Triano, DC, PhD; and Jacques Duranceau, MD, for providing constructive advice. The authors are indebted to those who assisted us during all or part of the project, including Drs Mark Laudadio, DC; Christian Eid, DC; Julie Roy, DC; Nicholas Beaudoin; and Mme Val rie Lambert, academic and technology support, Computer System Development Division at UQTR. Finally, we would like to thank Mrs Vicki Pennick, RN, BScN, MHSc, Senior Clinical Research Project Manager, Managing Editor, Cochrane Back Review Group, Institute for Work and Health for her valuable advice and pertinent comments and suggestions as a public representative. We further apologize, once again, to those who experienced temporary technical difficulties with the evaluation questionnaires at the onset of Website consultations (Delphi, Public and External review).

We wish to acknowledge all Delphi panelists who have dedicated their time to this project. The following is a list of Delphi panelists who have agreed to be acknowledged for their significant contribution to the research project.

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