Diagnostic Imaging of the Spine in Chiropractic Practice: Recommendations for Utilisation

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ABSTRACT: Diagnostic imaging, especially plain film radiographs, continues to be a mainstay in the assessment of chiropractic patients. Unfortunately, the lack of agreement between clinicians and even academicians on what constitutes proper utilisation of x-rays continues to plague the profession. This document will attempt to assert some reasonable boundaries on the proper utilisation of diagnostic imaging in the assessment of chiropractic patients, and will contain a panoramic overview of all the imaging modalities likely to be ordered by a chiropractor. Modalities which might be frequently ordered by sub-specialists in the field of imaging will not be discussed, mainly because their acquisition will not be the result of initial assessments rendered by the doctor of chiropractic.

INDEX TERMS: MeSH: chiropractic; radiography.

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PLAIN FILM RADIOGRAPHY
Diagnostic Plain Film Studies

Chiropractors acquire x-rays for a variety of reasons. Attempts to understand the rationale behind acquisition of x-rays in chiropractic practice as well as diagnostic yield for a variety of perceived or real phenomena have been published.

Clinical Indications for Films

The history and physical examination are considered sensitive indicators to the presence of therapeutically significant disease. Liange and Kamaroff determined the positive predictive value of the history and physical examination to be 99.8% for therapeutically significant conditions. The plain film series rarely reveals therapeutically significant information which was not elucidated in the clinical evaluation. Some feel that plain film x-rays should not be acquired unless the results of the exam could reasonably have an effect on therapy. The motivation for ordering radiographic studies is largely mediated by clinician preference rather than set criteria. Overutilisation may be the result of inexperience, habit, peer pressure, patient education or reassurance, and fear of litigation.

Hall et al. prospectively studied 19 clinicians at a chiropractic teaching clinic who ordered 1461 x-ray exams over a two-year period to determine their rationale for ordering radiographic series. The results showed that the vast majority (55.7%) acquired radiographs because of specific historical and/or examination findings. In no case was therapeutically significant information discovered which was not suspected from the history of clinical exam.

Deyo and Diehl have attempted to provide criteria for the proper, but not paranoid, acquisition of plain film radiographs in the out-patient setting. This attempt to establish and prospectively evaluate clinical criteria for ordering films met with less than optimal clinician compliance. The criteria established were designed to ferret out therapeutically significant conditions which would likely have positive x-ray examinations. The idea was to reduce the number of films acquired without sacrificing diagnostic yield or patient care. Kelen et al. also developed criteria for their emergency room physicians to utilise. Their criteria bore a resemblance to Deyo and Diehl's work.

Criteria modified from Deyo and Diehl's work were instituted at Los Angeles College of Chiropractic following retrospective evaluation of two consecutive years of radiographic studies performed at LACC. These criteria are listed in Table 1. In no instance was therapeutically significant information present on the radiographs which was not suspected from the clinical examination.

Diagnostic Yield

The plain film radiograph is considered an adequate first step in the evaluation of inflammatory joint disease, fracture, infection and neoplasm. In fact, Deyo
TABLE 1

FILM ORDERING CRITERIA FOR LACC

1. Age greater than 50 years
2. Trauma sufficient to cause fracture
3. Neurontin deficit
4. Unexplained weight loss
5. Suspicion or confirmed inflammatory arthritis
6. Drug or alcohol abuse
7. History of cancer
8. Use of steroids
9. Fever of unknown origin greater than 100°
10. Scoliosis
11. History of regional surgery
12. Failure to improve without prior x-rays
13. Medico-legal/governments

* Modified from Deyo and Diehl’s criteria

and Diehl found plain film radiography to be 90% sensitive to these therapeutically significant conditions.5

In chiropractic, mensuration and postural analysis are considered primary reasons to acquire radiographs. Zengle et al. performed an in vitro study attempting to demonstrate validity of mensuration on dry specimens connected by steel rods.6 The conclusion of this study was that certain, but not all, errors of positioning and distortion could be accounted for on plain film radiographs. Similar in vitro studies have cast doubt as to the efficacy of postural analysis in the laboratory setting.9,12

In vivo studies attempting to validate mensuration of the spine have met with severe criticism.12 Potential errors in mensuration have been attributed to structure,10,13,14 geometric distortion,13,15,17 and positional error.13,16,20

Intra- and inter-examiner reliability have been widely evaluated with respect to mensuration of the spine, and almost universally determined to be acceptably low in blinded studies.12,13,15,21 An exception to this is Jackson and co-workers’ study in which six experienced Pettibon practitioners were able to achieve inter-examiner reliability in marking upper cervical x-rays within .41 to .61 degrees.22 This might suggest that experience with a certain marking ritual might enhance inter-examiner reliability.

Bronfort and Jochumson evaluated sources of error and accuracy in mensuration using a digitiser. They determined that measurements of less than 1.7 degrees were just as likely due to error as they were to any change in the relationship of two adjacent segments.23 Schram and Hosek evaluated radiographs using a digitiser and determined that errors as small as .5 mm could create measurement error in excess of 5 degrees of rotation. They further concluded that 1.0 mm error in measurement could result in as much as 20 degrees of measurement error. They summarised that the results of their work were generalisable to the entire spine, and that any error in analysis greater than .5 mm could invalidate the results.

Beyond the potential for error and lack of reliability lies the issue of clinical correlation of the findings to the radiographs. Attempts to correlate the mensuration findings to signs and symptoms have failed miserably when objectively evaluated across populations. Studies comparing asymptomatic and symptomatic populations in the upright and recumbent postures have concluded that there is no demonstrable relationship between the presence of back pain and postural aberrances.24,25 In addition, literature assessing the therapeutic and diagnostic importance of plain film findings in the spine has demonstrated little usefulness.26,27 Patient satisfaction outcomes do not appear to be altered significantly as a result of pain film radiographs’ presence or absence.28,29

Routine radiographs acquired as a preemployment screen have been considered of diagnostic or prognostic value in relationship to the potential for the development of occupational back pain.24 This belief has come under severe criticism due to the extremely low diagnostic yield, unproven predictive value and prohibitive cost.25,30,31

In addition to postural and measured values, many findings encountered on radiographs are considered by the bulk of the literature to be of little clinical import. Congenital anomalies such as transitional segment, spina bifida occulta, facet asymmetry, vertebral body wedging, and transverse process length have failed to be more frequently seen in symptomatic populations when compared with asymptomatic populations.20,28,30,32,33 Attempts to establish a cause and effect relationship with back pain and other disorders such as degenerative joint disease, spondylolisthesis, scoliosis and Schmorl’s nodes have not yielded a positive correlation.21,28,29,31,40,41

Others still hold that these conditions, particularly transitional segment, tropism and degenerative disease have a role in the development of back complaints.28,45 While there is some evidence to suggest that degenerative disease can play a role in back pain, the predictability of developing pain, the duration, location, severity of symptoms and presence of complicating factors cannot be reliably ascertained from the radiograph.

Routine Series

Another issue of controversy centres around what constitutes a routine series. It is established that at least frontal and lateral views are the legal minimum for any region of the body.27,46,47 Beyond this, however, agreement ends.
Oblique views have classically been held in high esteem in the evaluation of low-back pain. The majority of published research does not hold such respect for these views, however. Most authors have determined the unique diagnostic utility of this view to be very low. The lateral lumbar-sacral spot view has suffered the same criticism in the literature.

**Full-Spine Radiography**

Standing radiography of the full spine was first developed by chiropractors as early as 1924. These radiographs, exposed on a 14” x 36” film, remain an important diagnostic tool in chiropractic to this day. Although this procedure has undergone considerable criticism for excess radiation exposure and overuse by chiropractors, much of the criticism is unwarranted. Research, in fact, has resulted in several technical improvements and developments. With proper attention to patient selection and technical detail, full-spine radiography is safe and effective.

**Patient selection** for full-spine radiography is subject to the same conditions as sectional plain-film radiography, but also has other unique indications. The frontal (A-P and P-A) full-spine radiograph is indicated for the following purposes:

- Scoliosis evaluation following clinical assessment;
- Evaluation of patients with multiple-level spinal complaints (except in cases where higher detail, sectional radiography would be more appropriate);
- Evaluation of complex biomechanical or postural disorders. The following, as isolated reasons for using full-spine radiography, are unacceptable:
  - Routine evaluation or screening of chiropractic patients;
  - Routine re-evaluation of biomechanical or postural disorders other than scoliosis;
  - As a routine replacement for sectional radiography.

**Stress Views**

Spinal radiographs acquired at the voluntary end range of a motion are frequently used for a variety of clinical circumstances. The purpose of spinal stress films is to rule in or rule out suspected ligamentous or (rarely) osseous compromise which renders one or more motion units structurally unstable. Table 2 lists some of the conditions considered clinical justification for the use of stress films.

Stress radiographs are acquired only after sufficient non-stress, plain-film convention studies are scrutinised. This helps ensure that the procedure is safe to perform. Stress films provide little unique diagnostic information for the demonstration of hypomobility, aberrant biomechanics or abnormal muscular activity.

The role of stress radiographs is established for the evaluation of ligamentous interruption in post-traumatic scenarios and inflammatory arthritis affecting the spine. Instability due to degenerative disease is probably more common than is published in the literature, and has important therapeutic implications. Stress radiographs are capable of identifying frankly unstable areas of the spine, however it is unlikely that subtle lesions of instability will be reliably uncovered using even carefully performed stress radiographs. Aside from obvious instability, little unique information can be obtained from radiographs that can not be obtained from the carefully performed clinical examination.

Case report and review articles have purported that stress radiographs are useful on a routine basis in the evaluation of mechanical back complaints. In these articles, the reliability of positioning, morphology, measurement and clinical correlation is assumed without statistical documentation or support.

Attempts to correlate the symptomatic state with stress film abnormalities have been unsuccessful. The acute low back can attain many postures with no particular posture reliably associated with any type or even group of abnormalities. The effects of degenerative disease, trauma, surgery and anatomical variation will have an effect on motion in the spine, but the significance of that effect is impossible to determine from plain film stress studies.

Evaluation of clinical correlation has not fared well in the chiropractic literature. Phillips concluded that the use of stress radiographs did not correlate well with the patient complaint or response to therapy.

Haas et al., in a prospective controlled evaluation of stress radiographs concluded that the poor clinical correlation between the radiographic findings and clinical findings rendered them a questionable technique.

A great deal of criticism has been leveled against the use of stress radiographs, largely because of technologic limitations and the fact that ionising radiation cannot be capriciously imposed on patient populations. Once again, the question of therapeutic impact is necessary to address first. A thoroughly performed

**TABLE 2**

**INDICATIONS FOR STRESS RADIOGRAPHS**

1. Degenerative instability
2. Traumatic instability (early or late)
3. Inflammatory instability
4. Late post-operative instability
5. Failed surgical fusion
6. Osseous failure (congenital or acquired)
7. High-risk ligamentous laxity populations
8. Scoliosis evaluation in growing skeleton
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clinical examination will provide more information in many instances than radiographs.

It is clear that the purpose of stress radiography is poorly defined in clinical practice. Opinions ranging from routine use to rare use abound. Radiographs have a limited, albeit important, role in the evaluation of mechanical disorders of the spine. The technology is frequently applied in a haphazard way, and the conclusions often require sensitivities which are unobtainable given the limits of knowledge and equipment. The more we seek to conclude from the radiograph, the greater the duty to ensure that the radiograph is a responsible messenger of that information. Understanding the limitations of the present technology with respect to radiography may prove useful in further defining many spine-related complaints. By preventing dubious or erroneous conclusions from radiographic studies, we may be able to reduce the cloudiness surrounding mechanical disorders. Instability appears to be an area of limited agreement with respect to the use of stress films, however a universally agreed upon definition of instability is still lacking.

VIDEOFLUOROSCOPY
Introduction

As early as 1897, the first fluoroscopic screens were introduced. Cineradiography utilising image intensifying screens and 16 or 35mm film emerged in 1921. In 1947, Jose Moretzsohn De Castro, a Brazilian medical practitioner, described his nine years of personal experience with cineradiography, focusing on evaluation of function of internal organs. In 1956, J. William Fielding attempted to describe normal motion in the cervical spine as visualised by cineradiography. Since that time, interest in the application of cineradiography to the study of the musculoskeletal system has grown, and there have been numerous articles published in the literature on this topic. Most of the literature to date deals with the cervical spine, however recent attention has also focused on the lumbar spine.

Equipment

A variety of types of machines are currently available. For clinical utility, exposure to the patient must be kept as low as reasonably achievable. Breen was able to reduce dosage in each plane (sagittal and coronal) to less than the same assessment with plain films. This is not, however universally achieved, as patient exposure levels vary from system to system.

It appears that the only quantification which can be done with real time fluoroscopy is using a digitiser. In general, the expense and training necessary to do good fluoroscopic studies of the spine renders this modality best suited to the laboratory.

Validating the Procedure

Breen describes a logical approach to validation of testing procedures as follows:

"Any procedure that seeks to quantify the difference between normal and abnormal should ideally fulfill each of the following criteria:
1) Calibration against a known standard.
2) Test/retest reliability.
3) Internal consistency.
4) Observer variability.

All this assumes a strong quantitative element in the procedure and its unambiguous definition."

There is no known in vivo standard by which videofluoroscopy can be judged. This situation is not unique to the validation of chiropractic procedures. "Test/retest reliability is difficult to assess when the biological material with which one is working changes with each test." Internal consistency is the ability of a test to change its outcome as outcomes of other tests (which cannot be done here as there are no scientifically valid means for determining normal spinal kinematics in vivo. The only method which remains is observer variability (i.e. the same results noted by multiple examiners or a single examiner on multiple occasions). This is the area that the majority of the studies on VF have addressed.

The only foreseeable means of quantifying intersegmentation motion in vivo is via advanced technology imaging systems such as digitised videofluoroscopy. It is important to remember that demonstrating reliability in measurement in no way guarantees clinical correlation or utility.

Definition of Normal

As early as 1958 Kottke and Lester stated "before this technic (sic) can be used to fullest value, standards of normal variations of vertebral motion will have to be established as a basis for evaluating abnormal cervical motion." Dimnet et al., in 1982, stated that the cineradiographic literature to date dealt largely with qualitative results and inexacty defined parameters, and that interpretation of the same studies was difficult for that reason. Despite numerous attempts to describe normal and abnormal motions in the cervical spine, Bell, in 1990, concluded that "normal and abnormal motion need to be described with more precision" and that, in fact, at that time "no developed method yet exists for quantifying fluoroscopic images."

Breen et al., in a study with digital VF on a single asymptomatic subject, noted the following: "interssegmental coronal plane rotation was not always regular, and if this phenomenon is common, similar degrees of irregularity in symptomatic subjects cannot be regarded as patho logical. Again, VF was able to demonstrate motion, but the clinical significance of such motion remains undefined.

A review of the literature dealing with normal cervical spine motion reveals that other than a study by Taylor and Skippings, no adequately controlled, well-designed studies with well-defined selection criteria exist. Most of the literature merely describes normal motion as the authors have witnessed it. It is from these descriptions of normal that an attempt at defining abnormal has been made.
Measurement

Measurement accuracy with videofluoroscopy (VF) is nearly impossible to achieve without digitisation. The sources of error are nearly infinite, specifically with respect to vertebral position.106

It would appear that for the purpose of visualising real-time spinal motion, VF is excellent, but as one attempts to quantify that motion, issues of reliability become very sticky.48 Without digitisation, numeric quantification of real-time VF is not reasonably possible.106

Clinical Utility

According to an extensive literature review performed by the Quebec Task Force on Spinal Disorders, the usefulness of VF as a diagnostic procedure to evaluate presumed radicular compression, confirmed spinal stenosis, and in asymptomatic individuals at six months or more post-surgery has been demonstrated by non-randomised controlled trial. The same Task Force concluded that there was no scientific validity to the use of VF for chronic pain syndromes, localised spinal pain, pain radiating into the extremities with or without neurologic signs, post-surgery from one to six months, or when asymptomatic six months or more after surgery.107 In addition, the role of fluoroscopy remains undisputed in interventional radiology and in the evaluation of gastrointestinal, myelographic and other studies requiring the injection of contrast material.

A great deal of information has been forwarded by the chiropractic profession as to the clinical utility of VF in the documentation of intersegmental dysfunction. The term “subluxation” is frequently used, but rarely defined in these papers. Bell, in a topic review article, purports that VF is an established, reliable method of evaluating spinal mechanics. He implies that VF is useful in the evaluation of joint motion. While the fact that joint motion is observed cannot be disputed, drawing conclusions about the normality on abnormality of that motion is unreliable, invalidated, and has not been evaluated for clinical correlation. He criticises the American Chiropractic Association for their position on VF,108 and states, “The question is not whether the procedure is helpful in the diagnosis of motion abnormalities; that has already been established.” He further states that the issues which still need addressing are: “What constitutes the best equipment? How do we interpret what we see? How can the images be measured? When do we use VF to evaluate patients?” It would seem logical, however, that when, how, why and what equipment to use should be addressed before unleashing this modality upon the public.

A variety of others have attempted to justify the use of VF in clinical practice. These take the form of literature reviews and case reports extolling the benefits of this procedure. Once again, the issues of normal vs. abnormal, reliability, validity, clinical correlation and therapeutic significance are either not addressed, or the conditions that they report success in demonstrating (i.e. instability, subluxation) are not defined, leaving the reader to form his or her own opinion.109-114

The issue of unique diagnostic utility has been addressed in the VF literature. Bailey performed a study in which he evaluated 40 cervical spines by comparing VF to flexion/extension stress films. The variables assessed in their study were: excessive motion, hypermobility and/or instability. None of these terms was defined for the purpose of the study. Using three radiologists, he concluded that VF was more sensitive and specific than plain films. Unfortunately he stated that for the purposes of the study, VF was considered the gold standard. This means that no false positives could be calculated from the data for VF. Further, there has been no literature ever published which documents the reliability or validity of VF, thereby qualifying VF as a gold standard, in the assessment of their undefined variables.115

Antos et al. evaluated the inter-examiner reliability of videofluoroscopic in the detection of cervical “fixations.” They defined fixation as those segments moving fifty percent or less of the distance between spinolaminar junctions in neutral position when flexed forward. Their methods involved stopping the videofluoro tape at neutral and full flexion positions so that mensuration could be made from the screen. It would appear that their study was more an assessment of inter-rater reliability of locating points and measuring distances on a TV screen than assessing inter-rater reliability of VF observations. They also stated that their definition of fixation was not in common clinical use, and might not be clinically useful. The examiners achieved 94% total agreement, however, in the discussion they stated that the agreement may have been overestimated due to the fact that both examiners’ measurements were obtained at the same “freeze frame” image on the TV, one immediately after the other.109

Jones stated in his comparison of cineradiography and stress views of 45 cervical spines that VF was “necessary” to demonstrate an abnormality in 17 of them. They still considered VF necessary when major diagnoses were apparent on plain film, but certain aspects relating to the timing of the motion were apparent only on VF. It should be noted that these findings (i.e. the timing of motion) did not alter treatment, which was usually surgical fusion. Only two cases of the 45 demonstrated abnormality which was not seen on the flexion/extension views. They concluded that the “total degree of instability or the combination of instability and restricted motion are no better depicted by cineradiography than by plain roentgenogram if adequate flexion/extension views are obtained.”116

From the literature presented, it is clear that the most reliable evidence speaks strongly against videofluoroscopy as a technique for clinical use at this time. There is limited evidence that certain indications for VF exist, but any attempt to quantify the findings therein remains without foundation. There is early evidence that high resolution digital fluoroscopy may prove a reliable method of measuring motion in the
spine but its developers feel that the cost and potential for error render it a modality which should remain only in the laboratory for the time being. Assuming eventual demonstration of reliability, the questions of clinical utility, diagnostic significance and therapeutic significance will require attention.

MYELOGRAPHY

Conventional myelography has few indications today. It is used on a very limited basis in the evaluation of cervical spine radiculopathy when the CT and/or the MRI findings are ambiguous. Some surgeons prefer myelography over MRI.

Metallic surgical implants, patient size, and claustrophobia sometimes preclude the use of MRI or CT.

Myelography has been effectively used for demonstrating the subarachnoid space, spinal cord and nerve root sheaths, however it is more costly and more invasive than CT or MRI, which can be performed on an outpatient basis. The diagnostic accuracy of MRI compares favourably with myelography, as well as visualising the internal matrix of the disc, the bone marrow, spinal cord and the surrounding soft tissues. CT also clearly outlines soft-tissue/fat planes allowing for gross visualisation of the thecal sac, and superb detail of the bony elements as well as the articulations. In most instances lack of availability of CT or MRI is the only rationale for ordering myelography rather than CT or MRI. Such a recommendation should come from a trained specialist after referral for a second opinion.

COMPUTED TOMOGRAPHY

Computed tomography is an important modality utilised in the imaging of various systems within the body, including the neuromusculoskeletal system and the abdomen. There is a variety of techniques used in conjunction with CT, including arthrography, myelography and intravenous contrast studies. Conventional tomography has been replaced by its successor, computed tomography, although it is still of practical use in limited clinical settings.

There are many prospective and retrospective studies, as well as numerous review articles which have described the usefulness of computed tomography in a variety of clinical situations and diseases. Many textbooks have been devoted to computed tomography in all aspects of body imaging. With the advent of magnetic resonance imaging there have been new studies to compare the efficacy and accuracy of these two modalities. Most of the comparative studies which have been done to this point are methodologically flawed, and they have not been of sufficient quantity nor quality to establish the superiority of MR imaging. In comparative studies, CT and MRI compare favourably, however most describe the superiority of CT in the evaluation of osseous detail.

CT as a Screening Modality

In most clinical settings, computed tomography should not be used as a screening exam in the evaluation of trauma. Computed tomography should be used in conjunction with plain film in the spine and other areas of the body. In general, regardless of what system of the body is being imaged, the plain film exam or other screening-type procedures such as scintigraphy should precede computed tomography. It is established practice that plain film x-rays be taken before computed tomography is performed in cases of musculoskeletal imaging.

CT Imaging of the Neuromusculoskeletal System

Computed tomography has become a widely accepted and important adjunctive imaging modality in the diagnosis and evaluation of musculoskeletal trauma. While computed tomography is both sensitive and specific in many types of musculoskeletal trauma, it must be reiterated that plain film x-rays should always be carefully evaluated before computed tomography is considered. There are, however, exceptions to this rule, most notably the skull. The advantages of CT in the evaluation of trauma are the excellent osseous detail and spatial resolution, good contrast resolution and cross sectional display of complex anatomy.

Computed tomography is now generally accepted as a simple, safe and reliable technique to evaluate cervical spine injuries. It is also a valuable tool in assessing thoracic and lumbar spine trauma. The advantages of CT in imaging spinal trauma are its ability to assess the spinal canal and impingement by osseous fragments and optimal evaluation of vertebral injuries in the axial plane. The paravertebral soft tissues are well evaluated, and there is little patient movement required during the exam.

Indications for computed tomography in spinal trauma include: when plain film x-rays are suggestive of or suspicious for a vertebral fracture, further evaluation of a fracture or dislocation, when the plain film x-rays and the neurological symptoms do not match, and when the lower cervical spine vertebrae cannot be adequately imaged with plain film radiography. There is a higher percentage of positive findings on CT scans when there are signs and symptoms indicating possible cervical spine or cord injury.

It has been suggested that CT is the modality of choice for evaluating occult fractures of the acetabulum and femoral head and to identify any intra-articular fragments. CT is an excellent modality to image sacroiliac joint fractures. CT surpasses plain film radiography in its ability to demonstrate fractures about the sacrum and S-I joints.

Most CT scans of the spine are performed on patients with low-back pain. Other reasons for ordering a CT scan of the spine include trauma, to rule out neoplasm or infection and to evaluate the other areas of the spine (cervical and thoracic).
The role of computed tomography in the evaluation of back pain is a complex and controversial topic. However, CT is relatively non-invasive (the exception being contrast CT), has excellent spatial and contrast resolution, and the ability to evaluate both osseous and soft tissue structures during a single examination. These make CT an excellent imaging modality for the spine, particularly in patients with the following symptoms: low back pain or sciatica, to demonstrate facet joint abnormalities, infection or suspected infection, radiculopathy and/or signs of nerve root irritation, chronic mechanical and neurogenic back pain, severe bony hypertrophy, suspicion of neoplasm or infection, evaluating or diagnosing various rheumatologic diseases, evaluation of complex congenital anomalies and dysplasias including spinal stenosis, recurrent disc disease, and metabolic disease.1-3,12-14,19

While CT is not a screening modality, some have suggested that CT is the most widely available and most effective non-invasive technique for demonstrating discogenic and bone-related pain.1-3,12-14,19 CT has been found to correlate well with surgical findings in cases of cervical radiculopathy and has a high degree of agreement with surgical findings in determining the absence or presence of herniated nucleus pulposus in the lumbar spine.14 CT is reported to be 74.1-96% accurate in the diagnosis of herniated nucleus pulposus.14,22-23,132,134,143 CT myelography increases the accuracy, particularly in post-surgical cases. It is clear that CT with or without contrast decreases in its accuracy of detecting herniated nucleus pulposus in post-surgical cases.14,134 CT is highly effective in identifying and evaluating bony changes within the spine, particularly the facet joints and correlates well with symptomaticology and surgical findings.12,132,134,136 CT appears superior for detecting lateral and far lateral disc herniations, as well as paraspinal abnormalities.12,138

Imaging of the spinal cord and thecal sac can be done with CT, often with a contrast agent introduced into the subarachnoid space. CT myelography can differentiate epidural from intradural lesions. Most intramedullary lesions can be distinguished from intradural extramedullary lesions as well.

Computed tomography has a secondary role in the evaluation of both osseous and soft tissue neoplasms.1-3,19

The major indications for CT in patients with neoplasms of bone or soft tissue include: Detecting the extent of the neoplasm, aiding in selection of biopsy sites, surgical planning and evaluating response to therapy.19 CT is most useful when the plain films do not adequately characterise the lesion or when there is uncertainty after magnetic resonance imaging.12,138,141 CT is best for evaluation of fine periosteal reaction, tumor mineralisation, and cortical integrity.19,135,138,141 It is recommended that CT or MRI imaging of solitary neoplasms be obtained before biopsy.19

MAGNETIC RESONANCE IMAGING

A brief glance through the literature reveals the widespread use of MR imaging for virtually every body system. Much of this is "testing the waters," so to speak, as MR is a relatively new modality, and a limited amount of research has been completed establishing the most appropriate indications for its usage in any given body area. Another problem is that significant, large-scale research cannot be performed fast enough to compensate for the rapid improvements of MR systems. Much of this literature is outdated before it is published.1,19 This should be kept in mind when perusing this section, as many of the current thoughts on MRI usage will more than likely change within the next few years.

Clinical Availability

Magnetic resonance systems have not diffused as rapidly as CT in the same time period. This probably reflects the technical and financial uncertainty of MR. At last report, there are about 2000 MRI units operating worldwide, 1200 of those being located within the United States. Unfortunately most of these are located in California and along the east coast of the U.S.A. Many areas have only one, or no available units. Except for Japan, most other countries have very limited access to MR scanners.19,19 Most of the increase in availability has occurred in the last couple of years, however, so access will more than likely continue to increase as MR gains acceptance.

MRI is best suited for stable, cooperative patients. It lacks significant streak or beam hardening artifacts from thick bone or metallic surgical implants, structures that often severely degrade the CT image.126-132,140,142

MRI vs Other Diagnostic Methods

Comparison studies with MR and plain film myelography indicate that MR is less expensive to perform. The most important element of the increased cost of myelography is the need to admit the patient to the hospital overnight.11 MRI has been found to be as sensitive and specific as plain film myelography in evaluating cord compression, in addition to having increased sensitivity in finding bony changes. It is usually better tolerated by the patient, is non-invasive, and less expensive.12,19

In the spine, there is still considerable controversy over which (CT or MRI) is the best initial imaging modality. While MRI and CT (with or without myelography) are of relatively equal sensitivity in evaluating herniated discs, many authors considered MRI the modality of choice because it is less expensive and non-invasive (if myelography is done), and does not expose the patient to ionising radiation. Other advantages of MRI over CT in general include direct multiplanar imaging, easily obtainable images of the entire spine, excellent tissue contrast, and the ability to detect myelopathies of the cord.12,123,144,145

MRI with intravenous contrast (Gd-DPTA) is very helpful in differentiating epidural scar from recurrent or residual disc material in the post-operative patient. Scar will enhance diffusely within 15 minutes, while disc may show minimal enhancement after 30 minutes.14,145

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At this time, MRI is not considered cost effective for routine use in many body areas. It cannot compete with scintigraphy in whole-body evaluation for suspected bone metastasis. The high cost of MRI contrast exams and limited availability will limit its role in determining disease activity in arthritis. Many insurance carriers still won’t cover MRI of the lumbar spine for suspected disc herniation.23,10-13,16,14,16-17

There is more difficulty differentiating herniated disc from posterior osteophyte in the cervical spine than in the lumbar spine using MRI. Evaluation of facet joint disease is less efficient with MRI than CT. In the trauma patient, CT and plain film radiography are the mainstay, especially in the acute phase.14-15

Disadvantages and Contraindications
Because of the magnetic fields generated by this procedure, there are some contraindications for having an MR scan. These include cochlear implants, metallic foreign bodies in the eye, ferromagnetic heart valves, intracranial aneurysm clips, IUDs with metallic loops, permanent TENS units, and some pacemakers. Additionally, because of the confined space in the scanner, patients with claustrophobia are not good candidates for this exam.14-15 It is still recommended that pregnant women forgo this procedure unless absolutely necessary, not because of any known complications, but because of the uncertainty of its effects.

There has been no evidence to suggest that significant heating of metallic implants occurs during this procedure, therefore most orthopaedic implants (joint replacements, etc.) will not constitute a contraindication to this procedure. The only problem that arises from these implants is focal image degradation.12-14

While most authors indicate that there are no known detrimental side effects to this procedure, it is still relatively new. One suggested complication is the potential for hearing loss after an exam performed on a high field strength scanner, secondary to the excessive noise of the machine during the exam.14

Most imaging studies of the spine, especially MRI, can demonstrate detailed anatomy and pathological changes, but cannot directly reveal their clinical significance.

Boden et al., in their study of 63 asymptomatic cervical spine patients found that 19% of the patients demonstrated at least one major abnormality on MRI. They emphasized the danger of predicting therapeutic decisions on diagnostic tests without precisely matching those findings with clinical signs and symptoms.15

SCINTIGRAPHY
Scintigraphy, also known as nuclear medicine scanning, is a highly effective imaging modality in the assessment of structure and function of many organ systems. It is a highly sensitive, but often non-specific, method of imaging.15 The scintigraphic scan allows the doctor to evaluate large areas of the body with relatively low radiation dose to the patient. In fact, scintigraphy is the most useful screening test for evaluating the entire skeleton for pathology.16

Scintigraphy is an imaging technique based on biochemistry, or more accurately, organ metabolism. The increased or decreased uptake of the radiopharmaceutical allows the doctor to visualise areas of abnormal metabolism in organs and organ systems. Metabolically sensitive bone scans may, therefore, detect lesions when plain film radiographic studies are un-revealing. Technetium-99m phosphate is the primary radiopharmaceutical used in skeletal scintigraphy.10 Technetium’s short half-life makes it useful for diagnostic radiology.10 Gallium-67 is the preferred radiopharmaceutical for imaging suspected infection or lymphoma.10-11 Gallium-67 is unsatisfactory for almost all other bone disorders.10 Many other radionuclides, such as radioisotopes of thallium and indium, are used to image non-skeletal organs.

Scintigraphy is the most commonly used imaging technique for the staging and evaluation of bone metastasis. Magnetic resonance imaging has greater sensitivity in detecting focal disease, however skeletal scintigraphy is the most useful screening test for the entire skeleton. Scintigraphy is a sensitive, but not a specific, imaging technique for detection of malignant tumors, because other conditions, some benign in nature, can result in positive tests.10 Degenerative joint disease, fractures, and infection can all result in an abnormal bone scan. Scintigraphic studies permit the early detection of stress injuries to bone, even when plain film radiographs are negative, therefore scintigraphy is the study of choice if clinically suspecting a stress fracture.12-13 Osteomyelitis and septic arthritis in their early stages may be diagnosed only by scintigraphic studies. In cases where infection is clinically suspected and a technetium-99m scan is equivocal or negative, a gallium-67 scan should be performed.

CONCLUSION
Diagnostic imaging is a considerably more complex field than it was 10 years ago. The advent and establishment of the many advanced technologies has changed the amount and clarity of imaging of the spine. Still, with all the anatomic precision which has evolved from this advanced technology, controversy about the meaning of the information to the clinician, as well as to the patient, abounds.

The key to the future of diagnostic imaging is drawing boundaries of reasonable use on appropriate populations. The spiraling cost of newer technologies has placed an unacceptable burden on third-party payer systems. The doctor using any form of imaging must now ask: How will this imaging study impact the therapy I deliver? It is only through the use of this type of approach to the acquisition of plain film as well as advanced imaging procedures that health care practitioners will be able to maximise the positive benefits of the technology without overburdening the financially responsible agencies.
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Book Review


The purpose of orthopaedic testing procedures is the clinical evaluation of a patient complaining of pain. One has to know the normal to recognise the abnormal; to be able to reproduce pain by reproducing the abnormal position or function; to understand the mechanisms which cause pain. This paraphrasing of a statement by Caillet explains the purpose of orthopaedic testing procedures. The tests are not diagnostic in themselves, they are designed to point out the area of involvement.

The expanded second edition is divided into 16 chapters. New chapters cover cranial nerves, nerve root lesions, reflexes, and cerebellar function tests. The use of the inclinometer in the measurement of range of motion of the cervical and lumbar spines has been included, as well as additional tests for possible compromise of vertebral basilar circulation. Each test is explained, the proper procedure illustrated, and indications of a positive test briefly discussed. This book is a handy tool to have available when needed.

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