A Litigation Primer On Diagnostic Imaging

Samuel D. Hodge, Jr.

There are different diagnostic tools for different purposes—and different ways of interpreting them.

AN EMERGENCY ROOM DOCTOR rushes a head trauma patient to the hospital radiology department to determine the extent of injury. An orthopedist refers a patient for an MRI to try to find out what has been causing the patient's nagging back pain. A family doctor suggests to a patient that she have a bone density test. An obstetrician recommends an ultrasound for a pregnant patient. What do all of these scenarios have in common? The physicians will rely heavily on diagnostic imaging to find out what's going on—and safeguard the patients' health.

Diagnostic imaging gives healthcare providers the ability to assess the internal structures of the body. Ever since Hippocrates painted a pa-

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tient's body with a slurry of wet clay and discovered that the mud dried quicker on the diseased area, physicians have sought ways to evaluate the condition of a bone, soft tissue, or organ within the body. Historically, this has been accomplished by palpating the structure in question. The inherent limitation in this approach is that the significance of an abnormality is subject to the clinician's interpretation. Search term *Medical Imaging*, http://encyclopdia.laborlawtalk.com.

The face of medicine changed in 1895 when Wilhelm Roentgen discovered the x-ray, thereby creating the first objective test for identifying anatomical abnormalities within of the body. Diagnostic medicine underwent another revolution with the introduction of the computer, allowing for physiological tests such as the bone scan, ultrasound, and electromyogram. These modalities allow the clinician to ascertain how an internal body part is functioning. As computer technology has advanced, imaging modalities have kept pace, with the creation the CT scan and MRI. These developments have brought a fresh approach to forensic documentation. Unfortunately, this equipment is not well understood by the legal community. This article will provide an overview of some of these procedures as well as their limitations.

DIAGNOSTIC RADIOLOGY • Diagnostic medicine involves the use of radiation to image a structure within the body. Procedures range from the plain film x-ray to the more sophisticated techniques which create three-dimensional pictures of the body. Dye is also used to visualize the soft tissue structures which are not normally visible on plain film x-rays.

Plain Film X-Rays

X-rays account for more than 75 percent of all imaging procedures. Beams passed through the body will cause a film plate to lighten or darken based upon the density of the body part through which the beam has passed. Solid bone is dense since it contains calcium phosphate and absorbs the radiation causing the film to be less exposed or whiter. X-rays, therefore, provide graphic evidence of a fracture or misaligned bone as well as degenerative changes such as bone spurs and loss of intervertebral disk height. Soft tissues, such as the brain, muscles, disks, and organs, have a very high water content and offer little resistance to x-ray beams. This causes the film to darken, so little detail is available for diagnostic interpretation. Therefore, this imaging modality offers little assistance in the diagnoses of soft tissue injuries including disc herniations and nerve root impingement. Although x-rays can provide graphic illustrations of anatomical abnormalities, the images must be taken in a variety of views and angles not to miss an elusive problem. Traditionally, the images have been stored on x-ray film but there is now an increased use of digitized images. Contraindications for the test are pregnancy, and a severe allergic reaction to the contrast dye.

Does The Test Aggravate The Complaints?

Physicians frequently order x-rays following an automobile accident but the utility of this practice must be questioned. It has been found

that radiography of the lumbar spine in patients with low back pain of at least six weeks duration does not correlate with improved patient function, severity of pain, or overall health status. In fact, having an x-ray performed results in a greater proportion of patients reporting low back pain at the three-month interval, a longer duration of pain complaints, and reduction in functioning. One possible explanation for this phenomenon is that the taking of an x-ray encourages the patient's belief that he or she is not well. Denise Kendrick et al., *Radiography of the Lumbar Spine in Primary Care Patients with Low Back Pain: Randomized Controlled Trial*, 322 Brit. Med. J. 400 (February 17, 2001).

Can X-Rays Support An Inference Of Soft Tissue Injury?

It is common for a radiology report following a car accident to note, "The cervical spine is negative for fracture but there is a straightening of the lordotic curve suggestive of muscle spasm." If an x-ray cannot visualize the soft tissues, how can it demonstrate spasms in the neck?

A soft tissue injury to the spine may occasionally be inferred from x-ray findings. The long muscles of the back run parallel to the spinal column and respond to injury with spasm. Since the muscles are attached to the various bony structures of the back, muscle spasm may be indicated by a change in the configuration of the spine. For example, there may be a straightening or reversal of the normal curvature of the back due to a pulling of the muscles. Samuel D. Hodge. ed., *Thermography and Personal Injury Litigation*, 10 (Wiley Law Publications, 1987). On the other hand, this type of abnormal finding is just as consistent with improper patient positioning or a pre-existing asymptomatic condition.

Are All Abnormal Findings Clinically Significant?

A number of investigative studies have demonstrated that a sizeable portion of the asymptomatic population have abnormal findings on x-ray imaging including spur formations, spondylosis, and disk space narrowing. These abnormalities are unrelated to trauma and the statistics should prove beneficial to the defense when attempting to discredit a physician's opinion causally relating the abnormality to the accident. For instance, a study of the lumbar spine of healthy people between 16 and 34 years of age found abnormalities in 58 percent of those x-rayed. J. Korber & B. Bloch, *The Normal Spine*, 140 Med. J. of Austl. 70 (Jan. 21, 1984). Other researchers have reported abnormal findings in 46 percent of the lumbar spines of patients which abnormalities had a very low correlation to their actual complaints and physical findings. 3 *Campbell's Operative Orthopaedics*, 3020 (S. Terry Canale, ed., Mosly Publishers, 9th ed., 1998). A study performed in England specifically examined the loss of cervical lordosis in the x-rays of patients presenting with neck pain and muscle spasm. The authors concluded that 42 percent of the normal population showed x-ray evidence of a straightening of the spine and women are more likely to have this abnormal finding. This led to the conclusion that their research failed to support the hypothesis that a loss of cervical lordosis reflects muscle spasm caused by pain in the neck. P.S. Helliwell and V. Wright, *The Straight Cervical Spine: Does It Indicate Muscle Spasm?* 76 J. Bone & Joint Surg. 103 (Jan. 1994).

If the average rate of clinically insignificant findings on plain film x-rays are between 40 percent and 58 percent, how may a physician state with a reasonable degree of medical certainty that an abnormality found on x-ray examination following trauma is causally related to the accident?

What Can X-Rays Tell The Defense?

From a defense perspective, x-rays taken shortly after the accident should be reviewed by a radiologist or physician performing the independent medical examination. Statistically, the chances of finding a pre-existing abnormality or obtaining a different diagnosis are high. Whether the pre-existing condition is the cause of the plaintiff's complaints and not the trauma of the accident creates a factual dispute to be decided at trial.

Venography

Venography is the x-ray examination of the veins after a contrast dye has been injected to make them visible. Venography is useful in locating blood clots, or suitable veins to use in coronary bypass surgery. Venography is also beneficial in distinguishing blood clots from obstructions in the veins, to ascertain how the deep leg vein valves are working, and in evaluating congenital vein problems. Although the test is very accurate in detecting deep vein thrombosis, venography is painful and exposes patients to high doses of radiation. Side effects include phlebitis, tissue damage, a severe allergic reaction to the dye, and the formation of deep vein thrombosis in a healthy leg. *Venography*, www.healthatoz.com/healthatoz/Atoz/ency/venography.jsp.

Bone Densitometry

Osteoporosis is a common disease process in which the body's bones become brittle making them susceptible to fracture. This condition occurs as a natural part of the aging process as bone loses its density and strength. Porous bones may occur anywhere in the body but a fracture is mostly likely to happen in the spine, hip, or wrist. Post-menopausal women are particularly susceptible to this problem but osteoporosis affects both sexes especially over the age of 50.

The Inadequacy Of X-Rays In Detecting Osteoporosis

Plain film x-rays are inadequate in detecting osteoporosis until a significant amount of bone density has been lost. This radiological shortcoming has been solved with the dual energy x-ray absorptiometry or "DEXA" test. This enhanced x-ray technique accurately measures bone mass density ("BMD") by sending a very low dose of radiation through the body via two energy streams. The first beam is absorbed by the soft tissues and the second by bone. The soft tissue amount is then subtracted from the total amount of absorbed energy and what remains is the person's bone mineral density. The test results are provided in the form of a T-score and Z-score. The T-score identifies the amount of bone the patient has as compared to a young adult of the same gender who enjoys peak bone mass. A score above -1 is considered normal but a finding between -1 and -2.5 is classified as osteopenia, the first stage of bone loss. The diagnosis of osteoporosis is made if the T-score is lower than -2.5. On the other hand, a Z-score reflects the amount of bone a person has as compared to other people of the same age group, size, and sex. If the score is unusually high or low, additional testing may be recommended. *See*: www.radiologyinfo.org/content/dexa.htm. Also, a patient's exposure to radiation is lower than that from the plain film x-ray.

Angiogram

An angiogram is an x-ray procedure that allows for the visualization of the heart and blood vessels. This invasive test requires the insertion of a catheter into an arm or leg through which a radio-opaque dye is injected. This contrast medium illuminates the area under study and shows a narrowing or blockage of a blood vessel, a pulmonary emboli, or an aneurism.

The test takes about one hour to complete and has the advantage of allowing corrective

measures to be immediately implemented such as the insertion of a stent or balloon to open a narrowed or blocked blood vessel. The test is usually performed with the patient awake and complications include bleeding, pain, bruising, and embolism formation.

Arthrogram

An arthrogram is the x-ray examination of a joint after an iodine-based dye and air have been injected into the joint. The test helps evaluate abnormal movements in the knee, shoulder, wrist, ankle, jaw, and hip as well as unexplained pain in these areas. The arthrogram is advantageous because it allows the direct visualization of soft tissue structures such as a ligament, muscle, tendon, or cartilage, which are ordinarily not visible on plain film x-rays.

The test is performed while the patient rests on an examination table and the clinician utilizes an x-ray beam, fluoroscopy, and other equipment to view the area being studied. Following the insertion of a needle, contrast material is injected into the joint and air is pumped into the area to expand the space being studied. This activity may cause pain or pressure in the joint. A series of x-rays are then taken with the hope of finding the soft tissue abnormality.

Myelography

Myelography allows the visualization of the spinal cord, nerve roots and disks. A contrast dye is injected into the dural sac or fluid filled area surrounding the spinal cord allowing the x-ray beam to peer through the back's boney structures to view the spinal cord and surrounding area. Because the dye is heavier than the spinal fluid, it is dispersed throughout the spinal canal by tilting the patient on the x-ray table up and down. Use of the procedure has declined in recent years because of the MRI but it remains valuable for detecting multiple level disk abnormalities, nerve root compressions, and spinal lesions. The invasive nature of the test, however, usually limits its application to those contemplating surgery or when the results of other diagnostic test are inconclusive. It is also used when a metallic objects is embedded in the patient's body thereby preventing the performance of an MRI. The main risk of this procedure is a spinal headache and patients may find the insertion of the myelogram needle painful. Patients are requested to stay in bed for several hours following the procedure with the head elevated.

A Bulge Is Not Always A Significant Injury

Test results must be carefully reviewed in a litigation setting because studies have found the detection of abnormal myelograms in the asymptomatic population to be a problem. A study as early as 1956 detected disc protrusion in 39 percent of the postmortem examinations of individuals believed free of such back problems. D.L. McRae, *Asymptomatic Intravertebral Disc Protrustions*, 46 Acta Radiology 9 (1956). Comparable findings were achieved a decade later when 37 percent of asymptomatic volunteers tested positive for disk abnormalities on myleographic examinations. W.E. Hitselberger and R.M. Witten, *Abnormal Myelograms in Asymptomatic Patients*, 28 J. Neurosurg. 204 (Mar. 1968). A recent study concluded that myelography, when employed in routine practice, is of limited value and helps to establish a diagnosis in only a minority of cases. M.J. O'Connell et. al, *The Value of Routine MR Myelography at MRI of the Lumbar Spine*; 44 Acta Radiologica 665 (Nov. 2003).

Computed Axial Tomography

Computed axial tomography or CT scan reveals the body's internal structures and detects soft tissue abnormalities such as bulging or herniated disks, tumors, and tissue swelling. A computer refocuses the x-ray beam to create a

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slice or cross-sectional view allowing a physician to exam a specific body segment and all of its contents at the same time. To use a loaf of bread as an example, an x-ray is only able to image the top, bottom, or side of the loaf. The CT scan, however, will cut the bread into slices, and will allow the viewer to examine any desired slice, including the crust and doughy part at the same time. These cross-sections are known as axial views and are frequently used to detect bleeding, swelling, and tumors.

How CT Scanners Work

The machine resembles a donut and the patient lies on a table nestled in a round hole located in the center of the device. An x-ray tube is then rotated around the person allowing the beam to pass through the body in a painless manner at different levels and angles. Multiple images are recorded during this process and reconstructed by a computer into slices for review. Dye may also be administered to provide more clarity or contrast to a specific body part. CT scanning poses the same dangers as plain film x-rays and the patient must remain still during the procedure for the technician to obtain clear images.

What Does A Positive Result Really Mean?

Even though the monetary demand in a soft tissue injury claim will dramatically increase following the finding of a bulging or herniated disc on CT scanning, these findings may not be clinically relevant. A study involving CT scanning of the low back in the asymptomatic population discovered that over 35 percent of these individuals had abnormal CT scans and more than 19 percent of those under 40 had herniated disks. In fact, a 50 percent abnormality rate was discovered in this age group with the most common diagnosis being stenosis or facet degeneration. S.W. Wiesel et al., *A Study of Computer Assisted Tomography: The Incidence of Positive CAT Scans in an Asymptomatic Group of Patients*, 9 Spine 549 (1984). Thus, the mere presence of a bulge or herniation on a CT image does not guarantee that a person will exhibit pain.

Discogram

A discogram is one of the more controversial procedures that was first used in medicine in 1948. The test is a radiographic examination of the internal structure of a disc to ascertain if it is the anatomical cause of back pain.

The procedure starts with the intravenous administration of a sedative. A needle is then placed into the center of the intervertebral disc and dye is released under fluoroscopic guidance. If pain is produced by this infusion of fluid, it is believed that the disc under study is the source of the patient's back pain. In addition, if the disc has ruptured or fissured, the dye will escape through the annulus or outer ring of the disc.

A discogram should only be performed when other diagnostic tests fail to reveal the cause of the patient's back pain. It is also common for a CT scan to be done following the completion of the discogram. Side effects include damage to the disc, increased pain, headaches, and hemorrhaging.

The Accuracy Of The Test Has Been Challenged

The validity of the discogram has been discussed in both the medical literature and court

decisions. Several cases have been mentioned the controversial nature of the test. For example, in *Dupree v. Insurance Company of North America*, 646 So. 2d 461 (La. Ct. App. 1995), the court noted that "a discogram is a controversial and questionable procedure because it relies upon the subjective reaction of a patient to pressure applied to the spine in order to determine whether pain is produced." Another court opined that the discogram is "somewhat controversial among orthopedic surgeons" and some physicians who do not perform the procedure find it lacking in reliability. The decision also noted that there is disagreement about what constitutes a positive discogram and the meaning of a positive test result. Although there is general agreement that the discogram is part objective and part subjective, it should only be one tool in the overall clinical picture and diagnostic work-up of a patient before surgery. *In the Matter of Falcon Inland Inc.,* 1999 W.L. 600373 (E.D. La. Aug. 6, 1999).

The Controversy In The Medical Community

The medical controversy involving discograms focuses on the subjective pain response of the patient and lack of controlled clinical trials. One article reported that pain at low pressure may be due to chemical irritation and not because of a disc abnormality. Steven A. Barna et al., *Discography,* www.emedicine.com/neuro/topic709.htm. Research conducted at Stanford Medical School concluded that patients with no history of low back pain who underwent bone grafting for non-lumbar procedures often experience pain on lumbar discography. Thus, the ability to separate spinal from non-spinal sources of pain on discography may be less meaningful than often assumed. Eugene J. Carragee, *False-Positive Findings on Lumbar Discography: Reliability of Subjective Concordance Assessment During Provocative Disc Injection*, 24 Spine 2542 (Dec. 1999). It has also been found that a high percentage of asymptomatic people with normal psychometric testing who had previously undergone lumbar discectomy will have significant pain on injection of their discs. This experience was found not to be significantly different from that of the symptomatic patients with normal psychometric testing undergoing discograms on discs that had previous surgery. The study also reported that individuals with abnormal psychological profiles have significantly higher rates of positive discograms than asymptomatic volunteers or symptomatic subjects with normal psychological screening. Eugene J. Carragee, Steve J. Paragioudakis, and Sanjay Khurana, *Lumbar High-Intensity Zone and Discography in Subjects Without Low Back Problems*, 25 Spine 2987 (Dec. 2000).

Researchers also examined the lumbar spines of healthy subjects through discography and found that the test was abnormal 17 percent of the time in the asymptomatic population. T.R. Walsh et al, *Lumbar Discography in Normal Subjects: A Controlled Prospective Study*, 72 J. of Bone & Joint Surgery 1081 (Aug. 1990). A link was also found between patients with abnormal psychological profiles and positive discogram results. This population had significantly higher rates of positive test results following disc injections than either the asymptomatic volunteers or symptomatic subjects with normal psychological screening. Eugene J. Carragee, *Provocative Discography in Patients After Limited Lumbar Discectomy: A Controlled, Randomized Study of Pain Response in Symptomatic and Asymptomatic Subjects*, 25 Spine 3065 (Dec. 2000). A similar research article found that the patient's pain intensity during discography is strongly influenced by the patient's emotional and psychological profile, chronic pain behavior, and ongoing compensation claims regardless of whether the subject has back pain or not. Eugene J. Carragee, *Is Lumbar Discography a Determinate of Discogenic Low*

Back Pain? Provocative Discography Reconsidered, 4 Current Rev. Pain 301 (2000).

Intravenous Pyelogram

Intravenous pyelogram ("IVP") marries the x-ray with a contrast dye to radiographically examine the kidneys and urinary tract. An iodine-based substance is injected into the arm and is eventually discarded through the kidneys. The soft tissues of the urinary system become illuminated by this contrast material allowing for their imaging. The test can reveal kidney stones, urinary tract obstructions, and tumors.

MAGNETIC RESONANCE IMAGING • The MRI creates sophisticated pictures of the body that resemble fine line drawings found in anatomy books. This diagnostic tool was initially known as nuclear magnetic resonance but the name was changed because of the negative connotations associated with the word "nuclear." The test was approved by the Food and Drug Administration in 1986. During its short history, the MRI has become the gold standard in helping diagnosis many medical conditions.

How Does It Work?

Magnetic resonance imaging combines a magnet, vastly more powerful than the magnetic pull of the earth, with radio waves to produce computer-generated images that can visualize bone and soft tissues in extraordinary detail. No form of radiation is used, the test is painless with no known side effects, and there is no known tissue damage. In fact, pregnant woman may have MRI testing performed.

The MRI is based on the principle that the nuclei in the body's hydrogen atoms act as tiny magnets. When stimulated by the MRI's magnetic field, about one-half of the nuclei line up in the direction of the magnetic field and the balance line-up in the opposite direction. These excited nuclei are then exposed to radio waves which cause the "tiny magnets" to change direction resulting in the emission of signals that are utilized to generate the final diagnostic images. Jim Feeney, *Magnetic Resonance Imaging—A Window into the Human Body*, National Institute for Medical Research, Mill Hill Essays, 1996, available at www.nimr.mrc.ac.uk/MillHillEssays/1996/mri.htm; Hodge, *Thermography and Personal Injury Litigation*, supra, at 17-21.

Sophistication Of The Images

The test is so sophisticated that slices of the spine may be created in multiple planes and in varying thicknesses. These views are:

- Sagittal, (side to side slices);
- Coronal (front to back slices); and
- Axial (top to bottom slices).

The variety of possible views provides great assistance in the diagnosis of herniated disks causing nerve root entrapment, or indentations into the spinal cord, tumors, infections, degenerative changes in the back and spinal stenosis. The studies even allow the visualization of very small tears to the muscles and ligaments and can discriminate between types of tissue within the same organ. Because the test can provide such clear images of the soft tissue structures near and around bones, the Radiological Society of North America, Inc. has noted that the MRI is the most sensitive exam for spine and joint problems. *MR Imaging (MRI)—Body*, Radiological Society of North America, Inc., June 1, 2004, available at www.radiologyinfo.org/content/mr_of_the_body.htm.

A Little Too Good?

Magnetic Resonance Imaging, however, may be "too good" at visualizing the anatomic details of the body. A number of investigative studies have demonstrated that not all abnormalities discovered on MRI scanning are clinically significant or the cause of the patient's

problems since multiple abnormalities have been discovered in the asymptomatic population undergoing MRI testing. *A Patient's Guide to Low Back Pain, Medical Multimedia Group*, L.L.C., (2003) at 12, available at www.medicalmultimediagroup.com/opectoc.html. One MRI study of the asymptomatic population ascertained that about one-third of those tested had significant abnormalities in the lumbar spine and herniated disks were found in 24 percent of these volunteers. J.C. Weinreb et al., P*revalence of Lumbosacral Intervertebral Disc Abnormalities on MR Images in Pregnant and Asymptomatic Non-Pregnant Women*, 170 Radiology 125-238 (Jan. 1989). A research article in the New England Journal of Medicine concluded that 63 percent of the asymptomatic population had disc abnormalities on MRI scanning and 38 percent had abnormal findings at more than one level. This prompted the scientists to conclude that the finding of a protruding or bulging disk in patients with low back pain may merely be coincidental. Maureen C. Jensen et al., *Magnetic Resonance Imaging of the Lumbar Spine in People Without Back Pain*, 331 The N. Eng. J. Med., 69 (July 14, 1994). Another research team found that 73 percent of the asymptomatic population have positive anatomical findings in the back at one or more levels with 37 percent of the subjects having herniated disks, 53 percent testing positive for bulging disks and 58 percent demonstrating annular tears. K.B. Wood et al., *Magnetic Resonance Imaging of the Thoracic Spine and Evaluation of Asymptomatic Individuals*, 77 J. Bone & Joint Surg. 1631 (Nov. 1995).

Additional Findings In Asymptomatic Population

Positive MRI findings in the asymptomatic population are not limited to the spine. For instance, the prevalence of rotator cuff tears in the shoulder was found in 34 percent of the asymptomatic population on MRI testing. These abnormalities increased with age and were compatible with normal, functional, and painless activities. J.S. Sher et al., *Abnormal Findings On Magnetic Resonance Imaging of Asymptomatic Shoulders*, 77 J. Bone & Joint Surg. 10 (Jan. 10, 1995). Another study found a wide array of abnormal magnetic resonance signals in the shoulders of young, asymptomatic people. Therefore, non-enhanced magnetic imaging may be of limited value in establishing rotator cuff injuries in patients with shoulder pain unless a full thickness tear is clinically suspected. A. Miniaci et al., *Magnetic Resonance Imaging Evaluation of the Rotator Cuff Tendons in the Asymptomatic Shoulder*, 23 Am. J. Sports Med. 142 (Mar.-Apr. 1995). In fact, small amounts of fluid which can be indicative of an injury, and the lack of preservation of the subdeltoid fat plane are routinely found in the shoulders of asymptomatic subjects. C.H. Neumann et al., *MR Imaging of the Shoulder: Appearance of the Supraspinatus Tendon in Asymptomatic Volunteers*, 158 Am. J. Roentgenology, 1281 (1992).

A number of investigative studies have demonstrated that not all abnormalities discovered on MRI scanning are clinically significant or the cause of the patient's problems since multiple abnormalities have been discovered in the asymptomatic population undergoing MRI testing.

Magnetic resonance imaging also detects abnormalities in the knees of healthy people. A study performed to ascertain the prevalence of

A bone scan is used to detect abnormalities involving the bones, including cancer that has metastasized, prosthesis loosening, subtle fractures, bone infections, and arthritis.

abnormal MRI scans of the knees of asymptomatic volunteers determined that almost seven percent of this test group had meniscal tears. In fact, more than 24 percent of those volunteers had Grade II signal changes in the posterior horn of the median meniscus. R.F. La Prade et al., *The Prevalence of Abnormal Magnetic Resonance Imaging Findings in Asymptomatic Knees: With Correlation of Magnetic Resonance Imaging to Arthroscopic Findings in Symptomatic Knees*, 22 Am. J. Sports Med. 739-745. An investigation at George Washington University Medical Center discovered that 16 percent of the asymptomatic test group had tears of the meniscus on MRI testing. The prevalence of meniscal tears increased from 13 percent in people under 45 to 36 percent in those older than 45 years of age. The authors concluded that the high incidence of abnormal MRI findings in the asymptomatic population underscores the danger of relying on diagnostic imaging without careful correlation with clinical signs and symptoms. S.D. Boden et al., *A Perspective and Blinded Investigation of Magnetic Resonance Imaging of the Knee: Abnormal Findings in Asymptomatic Subjects*, 282 Clin. Orthopaedics (Sept. 1992) 177-85.

In The Absence Of A "Pre-Accident" MRI, The Defense Should Point Out The Frequency Of Pre-Existing Conditions

Insurance adjusters and defense counsel should use these statistics to their advantage. It should be standard practice to ascertain if an MRI of the body part in question was performed before the accident. If yes, the pre- and post-incident images should be compared for change. The lack of an appreciable difference in these studies should render an abnormality meaningless as it pertains to the claim. An actual change in the pre- and post-accident studies may also have no trauma related significance but may merely reflect an advancement of a degenerative condition, such as a spur formation, discogenic disk disease, or desiccation, a process which involves the loss of water content in disks through the natural aging process. The lack of a pre-accident study also allows an abnormality to be challenged based upon the statistics presented in this article concerning positive MRI findings in the asymptomatic people.

NUCLEAR MEDICINE • This subset of radiology involves the use of small amounts of radioactive substances that are introduced into the body by injection or orally to image the body. It is also used to treat certain disease processes. About 16 million nuclear medicine images and therapeutic procedures are performed each year with about half of these exams being cardiac related. *What is Nuclear Medicine?* SNM Advanced Molecular Imaging, http://interactive.snm/org. Examples of these modalities include positive emission tomography ("PET"), bone scans, and single photon emission computed tomography ("SPECT").

Bone Scan

A bone scan is used to detect abnormalities involving the bones, including cancer that has metastasized, prosthesis loosening, subtle fractures, bone infections, and arthritis.

The first part of the test requires a radioactive material or radionuclide to be injected so that the physician can pinpoint areas of altered body function. It is known that radioactive dye is ab-

sorbed into a person's boney structures in areas of rapid bone turnover or remodeling. For example, healing fractures have rapid bone turnover due to the recalcification of the injured area. The scan will show this activity which is known as a hot spot.

The test may take up to four hours to finish since the dye must travel throughout the body and collect in the bones. Patients are also encouraged to drink water to cleanse the body of the unused dye. Another benefit of a bone scan is that the test is less expensive than MRI or CT-scan testing.

The Difference Between A Bone Scan And An X-Ray

A bone scan is the opposite of a standard x-ray which passes radiation through the body to create an image on film placed on the other side of the body. In a bone scan, the source of radiation is inside the body which travels to the surface where a special camera detects it. On occasion, a physician may order a three-phase bone scan which consists of a series of images taken over time. A number of pictures are made as the tracer is injected, then again shortly after the injection has been administered, and two to four hours later. Although the thought of having a radioactive substance injected into the blood stream may seem risky, the tracer doesn't remain active for long and its radioactivity disappears within one to three days. *Bone Scans: Using Nuclear Medicine to Look for Bone Abnormalities*, www.mayoclinic.com/invoke.cfm?id=ca00020.

Liver and Spleen Scan

This test pictorially exams both the liver and spleen with a gamma camera to evaluate these structures for disease. As with other nuclear scanning procedures, a radioactive substance is injected into a vein so that the tracer may travel from the blood stream to these specific organs in search of a cyst, abscess, problems with liver function and organ enlargement. Those parts of the liver and spleen where the radioactive dye accumulates in higher-than-normal amounts are revealed as bright or hot spots raising the suspicion of a tumor. Those areas where the tracer accumulates in lower-than-normal amounts are revealed as dark or cold spots which are consistent with a cyst, an abscess, or a collection of blood or a tumor. If the tracer fails to accumulate in the liver in the expected amounts or is unevenly distributed, hepatitis or cirrhosis is suspected. *Liver and Spleen Scan*, http://my.webmd.com/hw/hepatitis/hw232188.asp.

No special precautions are required for the test and images are taken about 15 minutes after injection of the radioactive material. The test is painless and there are no real known dangers associated with the procedure.

Positron Emission Tomography

A PET scan or positron emission tomography is a relatively new nuclear medicine study that provides images of the body's cellular function. This ability has excited the medical community because of its potential. The procedure is particularly useful in assessing the current status of cancer cells because it can show if the abnormal tissue is active and whether the cancer has metastasized. PET scans show promise in determining if areas of the heart that show decreased function are alive rather than scarred due to a prior heart attack. The test is also used in the brain to ascertain if a patient has a memory disorder such as Alzheimer's Disease. *Positron Emission Tomography*, www.radiology-info.org/content/petomography.htm.

A PET scan is performed by injecting a small amount of radioactive glucose into the blood stream which substance emits signals that are recorded by a scanner as the tracer completes its journey to the targeted organ. A computer then reassembles the signals into pictures which provide a biological map of normal

organ function or failure of an organ system. Jonathan Stein, *PET Scan* www.bocaradiology.com/Procedures/pet.html.

The test can produce false readings if the patient's chemical balances are not normal. For instance, the test results of a diabetic or a person who has consumed food within a few hours of the examination can be altered because of changes in blood sugar or blood insulin levels. Because the radioactive substance has a short shelf life, it must be produced in a laboratory near the scanning facility. This makes it quite important that the radioactive substance be injected at the scheduled appointment time to avoid a false reading. *Positron Emission Tomography*, supra.

Signal Photon Emission Commuted Tomography

Signal photon emission commuted tomography ("SPECT") pictorially depicts the blood flow through the brain, heart and other major organs in three dimensional images. Since it too is a test of nuclear medicine, a radioactive tracer is injected to help visualize the appropriate area. An application of SPECT is a scan of the brain which shows the clinician how well the various regions of the brain are functioning. *Brain SPECT*, www.amershamhealth-us.com/patient/diaguide/spect.html.

In fact, one study determined that it is possible to understand the differences between individual personality types at a functional brain level. R.M. Turner et al., *Brain Function and Personality in Normal Males: A SPECT Study Using Statistical Parametric Mapping*, 19 NeuroImage 1145 (July 2003). The American College of Radiology has noted that the clinical indications of SPECT include an evaluation of cerebral vascular disease, predicting the prognosis of a stroke patient, evaluating a patient with suspected dementia, and verifying brain death or traumatic brain injury.

The test requires no special preparation and is performed while the patient is sitting upright. The contrast material is fully distributed in the body within a few minutes of injection and the scan can be performed anytime during the first six hours. Radioactive exposure is equivalent to that used in a bone or CT scan. Daniel G. Amen and John R. Trudeau, *Why SPECT*, www.amenclinic.com/ac/why_spect.asp.

ULTRASOUND IMAGING • Ultrasound is an imaging technique that utilizes high frequency sound waves and their echoes to produce two-dimensional images of the organs of the body. The modality was developed as a military tool during World War II to help submarines navigate, and is akin to the sonar used by dolphins and bats. Because the test is non-invasive and uses no radiation, its medical applications are widespread and it is a popular test among physicians.

How The Test Works

The equipment consists of a computer, video screen, and small probe or transducer. The first step in performing an ultrasound is to liberally apply a gel to the area to create acoustical transduction. The probe is then pressed firmly against this moistened skin as the transducer is moved around. High frequency waves penetrate the body's tissues and rebound back to the hand-held device. A computer converts this information into images which become visible on the video monitor.

Ultrasound is useful in examining the organs of the body and in diagnosing:

- Tumors;
- Heart damage;
- The build-up of plaque inside a blood vessel;
- Retinal problems soft tissue masses;
- Abscesses;
- Gallbladder stones; and

- Liver disease.

Because the test is done in real time, ultrasound can pictorially display movement and function in the body's organs as they occur. Pregnant women can attest to the magic of the ultrasound after they have seen images of their unborn children moving about inside the womb. Major disadvantages of the procedure are that the ultrasound is highly operator dependant and the high frequency waves cannot penetrate bone.

Ultrasound Has Its Own False Positive Rates

Tears of the rotator cuff account for about half of all significant shoulder injuries. *Three Clinical Tests Reliably Diagnosis Rotator Cuff Tears*, American Family Physician, October 1, 2001, www.aafp.org/afp/20011001/tips/9.html. Counsel, however, must be careful when presented with diagnostic proof of a rotator cuff problem since that evidence may not be clinically significant. Research has demonstrated that an appreciable number of asymptomatic people have abnormal shoulder findings on diagnostic imaging. For instance, one research team found that 23 percent of healthy individuals had rotator cuff tears on ultrasound imaging. An astonishingly high number of rotator cuff tears were also demonstrated in the asymptomatic population as their age increased. The investigators concluded that rotator cuff tears must, to a certain extent, be considered normal degenerative attrition, not necessarily causing functioning impairment and pain. S. Templehof, S. Ruff & R. Seil, *Age-Related Prevalence of Rotator Cuff Tears in Asymptomatic Shoulders*, 8 J. Shoulder & Elbow Surg., 296 (July-Aug. 1999).

Some people advocate the use of ultrasound in the assessment of back trauma and pain. The American College of Radiology, however, has proclaimed that ultrasound has "no proven clinical utility as a screening, diagnostic or adjunctive imaging tool" for evaluating pain, nerve disorders or other subtle abnormalities adjacent to the spine. This opinion was seconded by the American Academy of Neurology which reported that no published peer review literature supports the use of ultrasound in the evaluation of patients with back pain or radicular symptoms.

ELECTRODIAGNOSTIC TESTING • The human body acts an electrical generator. Muscles and nerves produce electrical signals that transmit messages to and from the brain. Motor nerves send signals from the brain to activate the muscles allowing for movement. Sensory nerves, on the other hand, pick up stimuli from the environment, such as a pain response, and send the information back to the brain for action. Disease or injury to the nerves and muscles can alter the normal transmission time of these electrical signals. Physicians are able to arrive at a diagnosis by measuring the speed and degree of electrical activity in these soft tissues in people who suffer from weakness, pain or numbness in the neck, back, legs or hands. This measurement technique is called electrodiagnostic testing and is of great benefit in evaluating neuropathies and myopathties. *Electrodiagnostic Testing*, *Your Orthopedic Connection*, American Academy of Orthopaedic Surgeons, available at http://orthoinfo.aaos.org/main.cfm. The test consists of two parts—electromyography and nerve conduction studies and are generally administered by a doctor of physical medicine or neurologist.

Electromyography

Electromyography or EMG is the electrical testing of the health of a skeletal muscle and nerves that control that muscle. Some discomfort is associated with the procedure since thin needles are inserted along the muscle group and an electrical discharge is administered. The results of this stimulation are amplified and can be heard and seen on an oscilloscope. This pro-

cedure allows the clinician to ascertain how the muscles are working. After several weeks of compression of a nerve root, the muscles supplied by that nerve begin to spontaneously contract. By looking for abnormal electrical signals in the muscles, the test can demonstrate if a nerve is being irritated as it leaves the spine. *Trends in Pain Syndrome Diagnostic Technology*, Practical Pain Management (May/June 2004) at 12-31. Because an alteration in electrical activity is not immediately demonstrated, an EMG should not be performed for at least 21 days subsequent to an injury since it takes that long for the muscle to reveal recordable irritability.

Nerve Conduction Study

A nerve conduction study does exactly what its name implies. It is a test that measures how the nerves of the peripheral nervous system transmit or conduct electrical signals. When a nerve is injured or compromised, it will not transmit the electrical signals from the brain at their normal rate. This altered function can be measured by this electrodiagnostic study.

The test is performed by taping two small electrodes along the path of a nerve. An electrical signal is then administered and the time it takes for the signal to travel between these two points is measured. Electrical signals can travel up to 125 miles per hour in a healthy nerve. If the nerve is damaged, however, the electrical response will be slower and weaker thereby demonstrating that the nerve has been compromised along its pathway. *Electrodiagnostic Testing*, supra.

Electrodiagnostic Testing And Carpal Tunnel Syndrome

Electrodiagnostic tests are routinely use to evaluate carpal tunnel syndrome. This test, however, has its limitations and false positive readings. For instance, Colorado's Medical Treatment Guidelines note that electrodiagnostic studies require clinical correlation due to the occurrence of false positive and false test results. The procedure is also not capable of quantifying pain or determining if pain is even present. Since electrodiagnostic testing may be positive in asymptomatic individuals, carpal tunnel syndrome remains a clinical diagnosis which may not rest on the test results alone. www.coworkforce.com/dwc/rulexviirestore/rule_xvii_exhibit_b2.asp. Studies in the scientific literature support these warnings. For instance, 46 percent of healthy subjects in one study had at least one false positive electrodiagnostic test for carpal tunnel syndrome. M.D. Redmond & M.H. Rivner, *False Positive Electrodiagnostic Tests in Carpal Tunnel Syndrome*, 11 Muscle and Nerve 5, 511-18 (May 1988). Another paper demonstrated an 18 percent false positive rate on nerve conduction study. Isam Atroshi, *Diagnostic Properties of Nerve Conduction Test in Population-Based Carpal Tunnel Syndrome*, 4 BMC Musculoskeletal Disorders 9 (2003).

CONCLUSION • Diagnostic imaging has had a profound impact on the practice of medicine. Every area of the body can be assessed by one technique or another to ascertain if it has sustained trauma or has a disease process. All diagnostic tests, however, have limitations including false positive findings, and the detection of abnormalities in the asymptomatic population. The skill of the clinician also plays a large role in arriving at the proper diagnosis. Therefore, diagnostic testing is only one tool in the physician's overall assessment of a patient's condition. In a litigation setting, counsel must realize these limitations and not rely upon the results of a diagnostic procedure as the sole proof of a trauma-related injury. It is critically important to remember that diagnostic test results are only a part of the overall clinical picture.

PRACTICE CHECKLIST FOR

A Litigation Primer On Diagnostic Imaging

Diagnostic imaging technology has made great strides. But what diagnostic images show is still subject to interpretation.

• Plain film x-rays remain the most common imaging procedure. However, research has shown that radiography of the lumbar spine in patients with low back pain of at least six weeks duration does not correlate with improved patient function, severity of pain, or overall health status. Additionally, for instance, a study of the lumbar spine of healthy people between 16 and 34 years of age found abnormalities in 58 percent of those x-rayed.

• Venography is the x-ray examination of the veins after a contrast dye has been injected to make them visible. Venography is useful in locating blood clots or suitable veins to use in coronary bypass surgery.

• Plain film x-rays are inadequate in detecting osteoporosis until a significant amount of bone density has been lost. This radiological shortcoming has been solved with the dual energy x-ray absorptiometry or "DEXA" test. This enhanced x-ray technique accurately measures bone mass density ("BMD") by sending a very low dose of radiation through the body via two energy streams.

• An angiogram is an x-ray procedure that allows for the visualization of the heart and blood vessels. This invasive test requires the insertion of a catheter into an arm or leg through which a radioopaque dye is injected.

• An arthrogram is the x-ray examination of a joint after an iodine based dye and air have been injected into the joint. The test helps evaluate abnormal movements in the knee, shoulder, wrist, ankle, jaw, and hip as well as unexplained pain in these areas.

• Myelography allows the visualization of the spinal cord, nerve roots and disks. A contrast dye is injected into the dural sac or fluid filled area surrounding the spinal cord allowing the x-ray beam to peer through the back's boney structures to view the spinal cord and surrounding area. Test results must be carefully reviewed in a litigation setting because studies have found the detection of abnormal myelograms in the asymptomatic population to be a problem.

• Computed axial tomography or CT scanning reveals the body's internal structures and detects soft tissue abnormalities such as bulging or herniated disks, tumors, and tissue swelling. A computer refocuses the x-ray beam to create a slice or cross-sectional view allowing a physician to exam a specific body segment and all of its contents at the same time.

• A discogram is a radiographic examination of the internal structure of a disc to ascertain if it is the anatomical cause of back pain. A discogram should only be performed when other diagnostic tests fail to reveal the cause of the patient's back pain. It is also common for a CT scan to be done follow-

ing the completion of the discogram. The validity of the discogram has been discussed in both the medical literature and court decisions.

• Intravenous pyelogram ("IVP") marries the x-ray with a contrast dye to radiographically exam the kidneys and urinary tract.

• Magnetic resonance imaging ("MRI") combines a magnet and radio waves to produce computer-generated images that can visualize bone and soft tissues in extraordinary detail. No form of radiation is used, the test is painless with no known side effects, and there is no known tissue damage. A number of investigative studies have demonstrated that not all abnormalities discovered on MRI scanning are clinically significant or the cause of the patient's problems since multiple abnormalities have been discovered in the asymptomatic population undergoing MRI testing.

• A bone scan is used to detect abnormalities involving the bones including cancer that has metastasized, prosthesis loosening, subtle fractures, bone infections, and arthritis. A bone scan is the opposite of a standard x-ray. In a bone scan, the source of radiation is inside the body which travels to the surface where a special camera detects it.

• Signal photon emission commuted tomography ("SPECT") pictorially depicts the blood flow through the brain, heart, and other major organs in three-dimensional images. Since it too is a test of nuclear medicine, a radioactive tracer is injected to help visualize the appropriate area.

• Ultrasound is an imaging technique that utilizes high frequency sound waves and their echoes to produce two-dimensional images of the organs of the body. The American College of Radiology, however, has proclaimed that ultrasound has "no proven clinical utility as a screening, diagnostic or adjunctive imaging tool" for evaluating pain, nerve disorders, or other subtle abnormalities adjacent to the spine.

• Electromyography or EMG is the electrical testing of the health of a skeletal muscle and nerves that control that muscle. Thin needles are inserted along the muscle group and an electrical discharge is administered. The results of this stimulation are amplified and can be heard and seen on an oscilloscope.

• A nerve conduction study is performed by taping two small electrodes along the path of a nerve. An electrical signal is then administered and the time it takes for the signal to travel between these two points is measured.