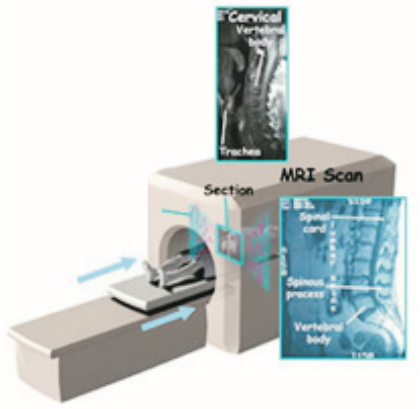
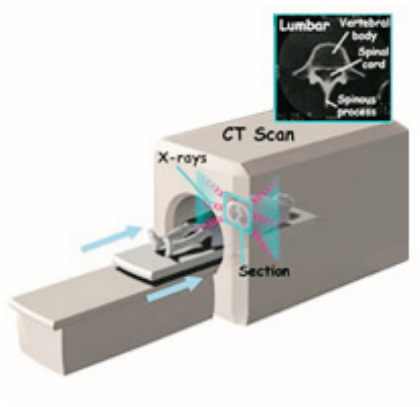
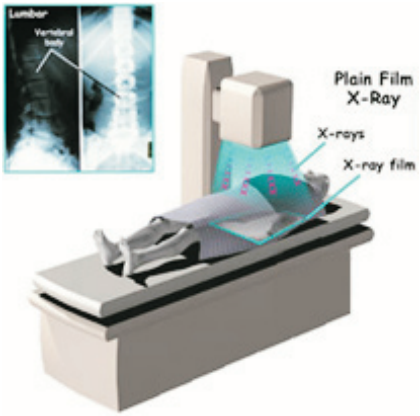
• **Magnetic resonance tomography (MRT, or nuclear magnetic resonance, NMR)**



• **Computer tomography (CT)**



• **Conventional (plain film) x-ray**



Conventional x-ray

What is conventional (plain film) x-ray?

Conventional x-ray diagnostics are still in use today as a basic investigatory diagnostic method for the bones and thorax. Images of the spinal column, for example, are created by x-rays, projected onto x-ray film, which is then developed to show the projected image of the segment. Conventional analog x-ray methods using x-ray film for imaging are now increasingly being replaced by digital methods in which the system consists of a detector with an analog-digital converter.

What imaging techniques are used?

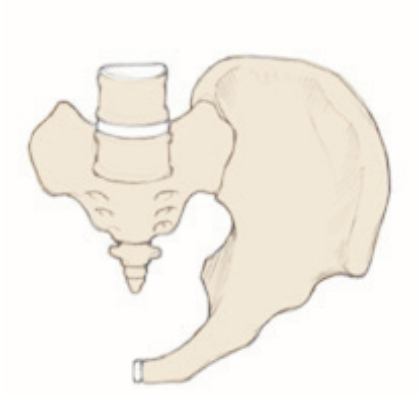
The following imaging techniques can be used to facilitate spinal column diagnostics:

· Spinal column image in 2 planes, AP and from the side
· Angled images for assessment of the neuroforamina, facet joints and interarticular portions in spondylolysis
· Survey images of the spinal column in a standing position in 2 planes, to depict and measure spinal column deformities
· Survey images of the spinal column AP in extension (Cotrel or halo-extension equipment) to assess the extent to which a lateral deviation from scoliosis can be straightened
· Bending test to assess whether lateral deviations of the spinal column can be spontaneously corrected or are already fixed
· Stagnara method: an x-ray in a selected plane, an angled image of the spinal column for the improved assessment of kyphotic scolioses
· Risser method: AP x-ray of ilium aponeuroses

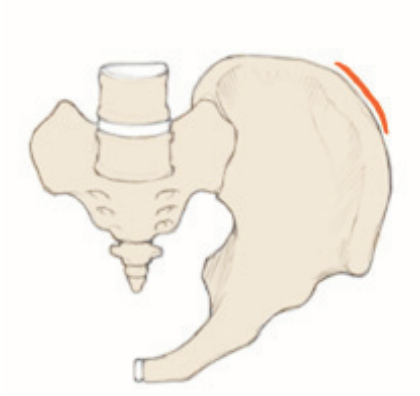
Determination of skeletal age is important when assessing future progression of an existing spinal column deformity. The pelvic crests are imaged and further skeletal growth can be projected on the basis of the degree of ossification of the pelvic crest apophyses.

Risser's sign assessment of skeletal age

• Stadium 0



• Stadium 1



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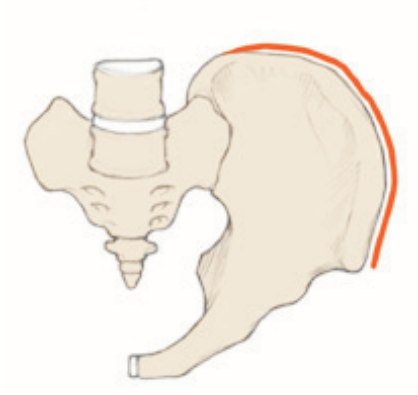

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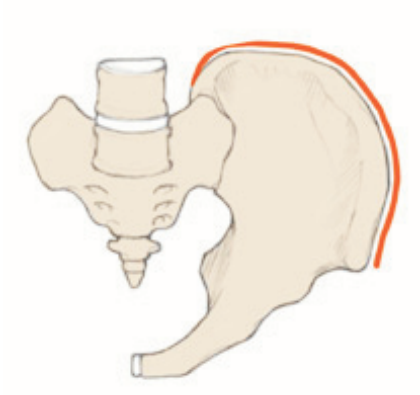
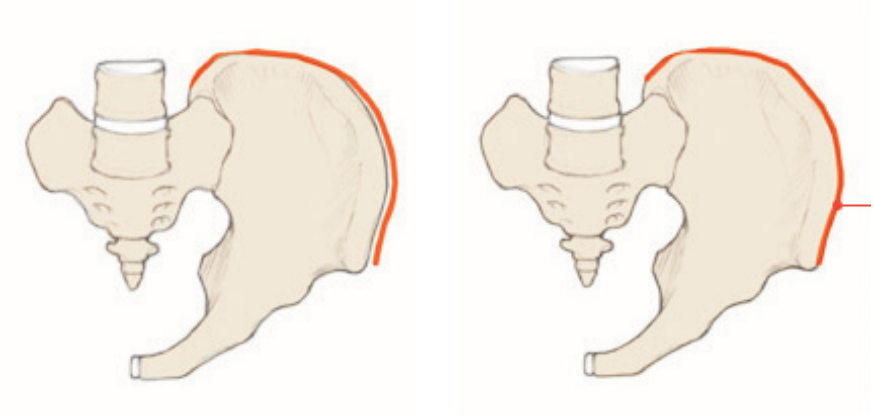


• Stadium 4

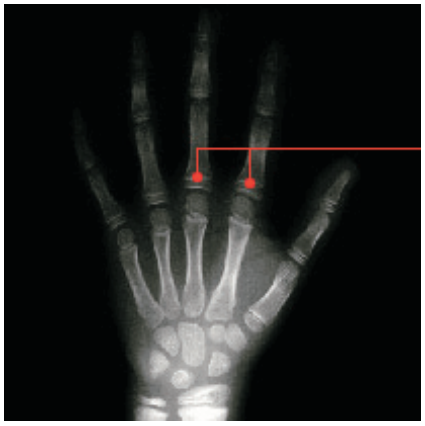
• Stadium 5



· • Increasing ossification of the pelvic crest apophyses

· Greulich and Pyle method: AP x-ray image of the hand to assess skeletal growth, where the increasing closure of the epiphyses (active growth areas of the long (tubular) bones) of the hand skeleton is used as the basis for the projection of further skeletal growth.

• AP x-ray image of the left hand

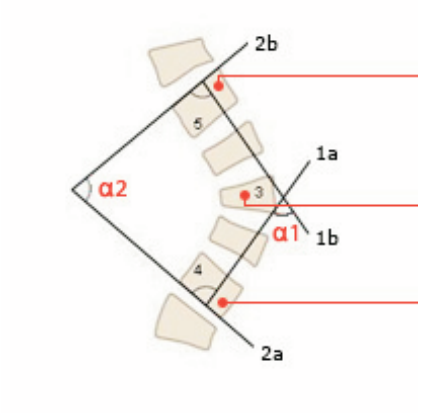


· Digital epiphyses

· Cobb angle measurement in scoliosis

The degree of lateral curvature in scoliosis is determined on the basis of a survey image of the spine in a standing position. A vertical line (1a) is drawn from the apical vertebra (3) at right angles to the plane of the base plate (2a) of the lower neutral vertebra (4) and another vertical line (1b) is drawn at right angles to the upper plate (2b) of the upper neutral vertebra (5). The point of intersection of the two vertical lines shows the á1 angle of lateral deviation (angle of scoliosis). The á2 angle at the point of intersection of the planes of the lower and upper neutral angle is the identical alternate angle, i.e. also equal to the angle of scoliosis. Since this angle often lies outside of the x-ray image, the corresponding á1 angle is generally used.

• Cobb angle measurement in scoliosis



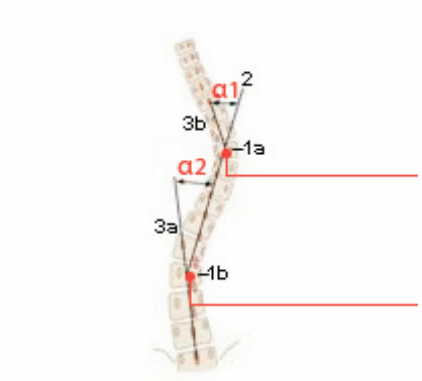
· Upper neutral vertebra

· Apical vertebra

· Lower neutral vertebra

· The Ferguson angle measurement of curvature is more complex and is used less frequently than the Cobb method. The measurement points used are the upper (1a) and lower (1b) apical vertebrae, connected by a straight line (2). The midpoints of the vertebrae below and above the apical vertebra are joined by straight lines (3a, 3b). The points of intersection of these straight lines with the straight line 2 show the angles of curvature á1 and á2.

• Ferguson angle measurement in scoliosis

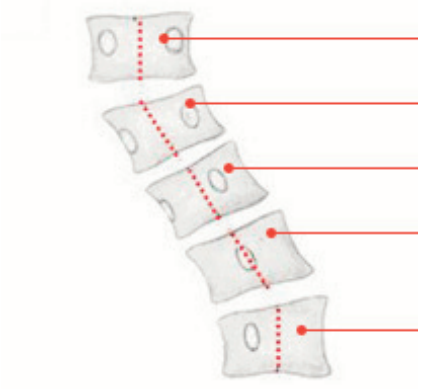


· Upper apical vertebra

· Lower apical vertebra

· Nash-Moe rotation assessment
This method is used to determine the degree of rotation of the scoliotic spinal column. In the x-ray image, the positions of the pedicles in relation to the vertebral body are assessed in terms of 4 different degrees of rotation.

• Nash-Moe rotation assessment method Concave side



· a: Normal findings, no rotation

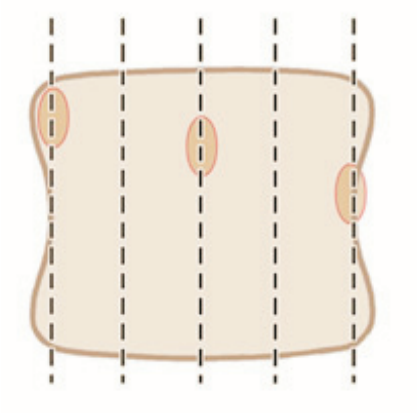
· b: Degree of rotation I

· c: Degree of rotation II

· d: Degree of rotation III

· e: Degree of rotation IV

• Projection of the pedicles based on the rotation of the vertebra



Concave side

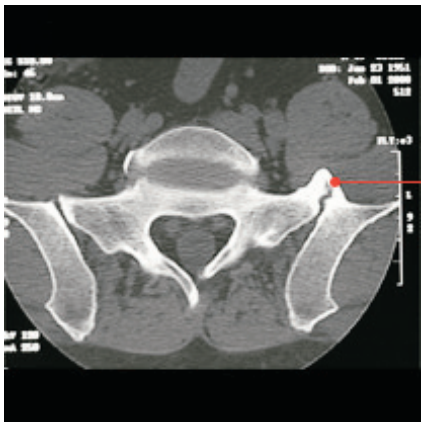
Computer tomography, CT

Computer tomography (Greek tomos, cut and graphein, to write) is a special x-ray technique used to generate sectional images of specific regions of the patient‘s body. The English engineer Hounsfield developed the first computer tomography in 1971. The first CT system for sectional imaging of the head was installed in 1972 at Atkinson Morley´s Hospital in London.
How is a CT image generated?
An x-ray tube is rotated around the patient on the examination table while the patient is moved forward through the x-ray tube. The emitted x-rays are attenuated to varying degrees when they penetrate the various different tissues in the body regions being examined.
These variations in attenuation of the x-rays are recorded by detectors and sent to a computer that can generate sectional and 3D images of the examined region from this data.
The sectional images are generated in sequence at millimeter intervals, facilitating the evaluation of the entire region.
Electron beam tomography, EBT, is a further development of CT with a much faster rate of recording, allowing for sharply focused sectional imaging of moving organs such as the heart.

Indication
The diagnostic focus of computer tomography is on depicting the abdominal and pelvic organs and the thorax. It is also a highly effective diagnostic tool for diseases of the bones, joints and spinal column.
3D reconstruction of CT images has proven very useful in the diagnosis of certain diseases of the spinal column, such as congenital deformities and tumors.

• Computer tomography, source: Siemens

• CT: Arthrosis of the sacroiliac joint



· Arthrosis of the sacroiliac joint

Magnetic resonance tomography, MRT or nuclear magnetic resonance, NMR

Magnetic resonance imaging differs from computer tomography in that the patient is not exposed to x-rays. Magnetic fields and radio waves are used in this imaging method instead.
NMR tomographs have been in clinical use since 1984.

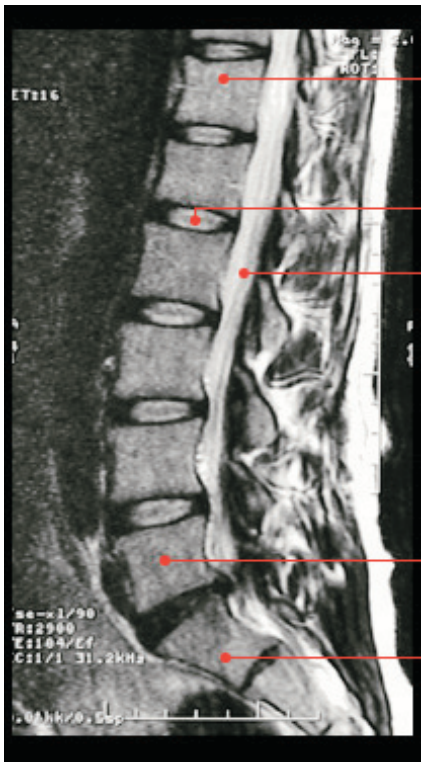
How is an MRT image generated?

MRT images use the fact that the human body is composed of up to 90% water and the magnetic property of the hydrogen atom nuclei in body tissues. In the MRT system, these hydrogen atoms are exposed to a magnetic field that is as much as 30,000 times stronger than the earth's magnetic field, whereby pulsed radio waves cause them to resonate. The varying energy signals given off by the hydrogen atom nuclei are captured and recorded by the MRT equipment, then converted by means of a complex mathematical process into sectional anatomic images of the body regions under examination.

Indication
Magnetic resonance tomography produces highly accurate images of all body tissues. The method is particularly well-suited to examination of soft tissues such as the brain, spinal cord, nerves, intervertebral discs, blood vessels and tumors.
Since patients are exposed to a strong magnetic field in this procedure, persons wearing electrical implants such as cardiac pacemakers cannot be examined with MRT.

• Magnetic resonance tomography,
source: Siemens

• MRT image of the lumbar spine from the side



Myelography/myelo-CT

The spinal cord (myelon) and the emerging nerve roots are surrounded and protected by the dural sac, which is filled with cerebrospinal fluid (liquor) in the subarachnoid space. Myelography is a diagnostic method used to make images of the subarachnoid space using a water-soluble contrast agent.
How is myelography performed?
As a rule, the lumbar back region is disinfected, followed by sterile puncturing of the dural sac and injection of the contrast agent into the spinal canal.
When the contrast agent has been uniformly distributed around the spinal cord and emerging nerve branches, x-ray images are made at different levels, allowing for the assessment of the various segments of the spinal canal.
Computer tomography is often done following this examination.

Indication
Myelography can be used to diagnose spinal cord processes, disc prolapses and spinal canal stenoses.
Myelography is still one of the most important neuroradiologic diagnostic methods for the spinal column. Considered defunct only a few years ago, the method has received increasing attention in recent years. The reason for this is that myelography is currently the only available method capable of dynamic imaging.
This makes it possible to diagnose pathological changes that only manifest under dynamic conditions, i.e. under a weight load.
In spinal fusioning or disc replacement surgery in particular, myelography is a valuable tool for assessing the status of both the affected and neighboring segments.

• Myelography of the cervical spine, AP

• Myelography, of the cervical spine, side view

Discography and post-discography CT

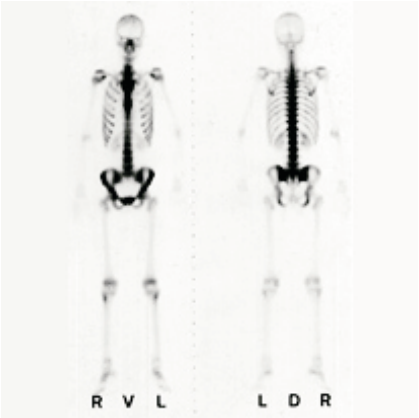
This imaging method is particularly important within the framework both fusioning and mobility maintenance surgery, since only the combination of NMR and discography can provide a relatively accurate picture of the functional status of the spinal column. The degenerative processes are graded in degrees according to Adams, allowing for an extremely accurate assessment of the extent of degeneration.

Scintigraphy

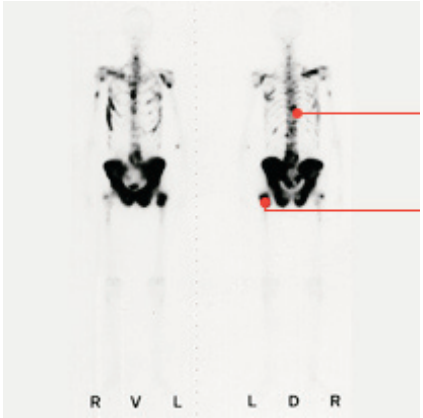
Scintigraphy is a nuclear diagnostic procedure used to obtain an image of the “functioning” of organs or tissues by means of the administration of substances with low-level radioactivity (radionuclides) with short half-lives.
How is a scintigram obtained?
After the radionuclides have been administered to the patient, these substances accumulate in patterns in tissues and organs that reflect current metabolic activity levels. The radionuclides give off gamma radiation that is recorded by scanners or a gamma camera. The data thus obtained is fed into a computer that generates an image of the region examined.

Indication
Scintigraphy is used to detect diseases of the thyroid gland, heart, brain, lungs and bones. Bone scintigraphy can render clearly defined images of inflammations and tumors.

• Normal survey skeletal scintigram showing typical radionuclide distribution.
Image released by DGN/Moser/ Freiburg



• Scintigram of a patient with bone metastases showing clearly circumscribed areas of increased radionuclide enrichment in the vertebral bodies, ribs, and left femoral neck



· Vertebral metastasis

· Bone metastasis in left femoral neck