A system for evaluating the spine includes:

1-HEIGHTS OF THE VERTEBRAL BODIES AND INTERSPACES
2-BONE DENSITY
3-FACETS (the Scotty dog)
4-NEUROFORAMINA
5-ALIGNMENTS
   facets
   margins
   spinous and transverse processes
6-SOFT TISSUES

Whether it is cervical, thoracic or lumbosacral spine films, the system is valid.

In evaluating the heights of the vertebral bodies, compare the vertebra above and below, and look for any cortical wrinkles. If a compression fracture is present you will need to compare any old available films to determine its age. You will also need to recognize typical Schmorl's nodes and limbus vertebrae, examples of which are shown in the figures below.

\[ Figure \#139 \text{ (left).} \] Black arrows point to typical Schmorl's nodes which indent the normal vertebral margins on either the inferior or superior surface. They can be considered a normal variant as a result of notochordal remnants, or some people have attributed them to trauma, where a portion of disc material is forced into the adjacent vertebral cortex. If the defect appears after a prior film shows none, then certainly a traumatic Schmorl's node can be diagnosed. Most, however, are of no clinical significance.
Figure # 140 (left). Ununited ring apophysis as indicated by the white arrows represents a limbus vertebra and should not be mistaken for a fracture.

Figure # 141 (above) and # 142 (left). AP and lateral views of the L-S spine. Note that the heights of the vertebral bodies are equal throughout. The intervertebral disc spaces are also equal although they appear narrower cephalad. This is because the central ray of the x-ray beam is centered over the L3 vertebra (white octagon) and as it “fans” out causes some distortion of the image. Note also that the bone density of the visible vertebrae is even. The “Scotty Dog”, illustrated by the red line, is an important landmark. The dog’s neck represents the pars interarticularis, and the film interpreter should look for a defect or “collar” (spondylolysis) at all levels on each film. Neuroformina are the spaces (outlined in white) above and below the Scotty dog. These spaces allow nerves to exit from the spinal cord and are better evaluated by CT or oblique views, but encroachments such as caused by osteophytes are easily seen. Note that the anterior vertebral margins align in a smooth curve (pink line). The posterior spinous processes do likewise, (green line) although not all are seen in this reproduction. One should also look at each facet in the AP view for integrity and alignment (white arrows) and the posterior spinous processes (blue arrows) which project over the next adjacent interspace. Occasionally one will detect a defect such as a spina bifida occulta indicated by the curved red arrow in figure 141 above by the white arrow in figure 143 left.

Figure # 143 (left). Gives you a better look at a spina bifida occulta of the 5th lumbar segment (white arrow).
Figure # 144 (left). The oblique view of the lumbar spine demonstrates the “Scotty Dog” much better than the lateral view and is often ordered to evaluate the pars interarticularis.
1- Body of L-2 vertebra
2- Disc
3- Transverse process of L-4, the “nose”
4- Pars interarticularis of L-4, the “neck”
5- Superior articular process of L-5, the “ear”
6- Pedicle of L-5, The “eye” of the Scotty Dog.
7- Inferior articular process of L-5, the front leg of the dog.

If you see a collar (defect) across the dog’s neck, it represents a spondyloysis. These defects may be the result of a birth defect, or trauma (un-united fracture). These can lead to an unstable back with subluxation of a vertebral body called spondylolesthesis. Illustration courtesy of RAOnline via the Internet.

Figures # 145 (left) and # 146 (sketch right) shows the classic collar on the Scotty Dog of a spondyloysis defect.

Figure # 147 (left and right). Stage I anterior spondylolesthesis of L-5 on the sacrum is demonstrated with an associated spondyloysis (white arrows). Note that the posterior margin of L-5 (red Arrows) has slid forward (anterior) on the sacrum (S). A stage II slip would be further subluxation to about 50% of the opposing surface and a stage IV would be almost complete displacement.
The intervertebral disc spaces can be difficult to evaluate if the patient has scoliosis or the patient is positioned less than optimally. One way to solve this dilemma is to mark the inferior edge of one vertebra and the superior edge of an adjacent vertebra with wax crayon, always using either the most superior or the most inferior margins of both apparently tilted vertebrae. You can then observe the height of the disc space readily and measure if necessary. This process is illustrated in figures 142-143.

Recognition of bone density abnormalities comes with experience and familiarity with a particular radiology department’s technique. One way to gain that experience rapidly is to guess the patient's age when looking at spine films and then confirm your estimate. After awhile you'll get pretty good at it. Bone mineral loss is reported by radiologists as osteopenia or osteoporosis and results in darker skeletal structures on the radiograph. Increased density, on the other hand, is termed eburnation or increased bone density and is usually described with other findings which will help the referring physician determine the cause.
Isolated areas of increased bone density in a male over the age of 60 are prime suspicion of metastatic carcinoma, particularly of the prostate. Of course this finding oft times has to be differentiated from Paget's disease which is relatively easy once you remember the four radiographic signs of Paget's which are:

1-thickened cortex  
2-coarse trabecular pattern  
3-deformity or enlargement (due to soft bone)  
4-increased density

Sclerotic metastatic carcinoma of the prostate (or other primary site) does not result in thickened cortex or course trabeculae. Instead the trabeculae often become smudgy looking. Both can result in increased density of bone and deformities, the latter in metastatic ca often due to pathologic fractures. These points are demonstrated in the next illustrations.

**Figure # 151 (left).** Magnified view of normal bone cortex and trabecular pattern.

**Figure # 152 (right).** Normal vertebrae.

**Figure # 153 (left).** Magnified view of bone cortex and trabecular pattern in Paget's disease. Note coarsened trabeculae.

**Figure # 154 (right).** Note the dense thickened cortex of a vertebra with Paget’s involvement. Compare to the normal above. This appearance is often said to resemble a picture frame. Image courtesy dirt museum via the Internet. Thanks to Dr. Ian Maddison, MA. BM. BCh. MRCP. FRCR. Reprinted with permission.
Metastatic ca of the breast can result in either increased or decreased bone density depending on the host’s defensive reaction and the cell type. Shown below are two cases illustrating this point.

Step 4 in the system of the spine is evaluating the neuroforamina, and this is most important in the cervical spine in which they are well seen in oblique views. Encroachment by osteophytes is a common finding and explains the cause of many patients’ parathesia symptoms. When associated with degenerative disc disease the findings are termed spondylosis (not to be confused with spondylolysis, the defect mentioned previously).

Figures 142 (previous) and 159 (next page) show normal neuroforamina as opposed to a patient with cervical spondylosis.
In the cervical spine, alignment evaluation is extremely important in evaluating trauma victims. The initial film is usually a cross-table lateral view. In this projection one should check the upper portion of the cervical spine in relation to the clivus, the extended line of which should intersect the odontoid in its posterior one third. Also the posterior and anterior vertebral margins should align fairly close in this view, as should the facets, pedicles and neuroforamina in the oblique projections.

Remember that position and alignment of cervical vertebrae are maintained by ligaments, which may be stretched or fractured, and there may not be an associated bone injury.

If flexion and extension views are provided, keep in mind there is a great deal of "normal" subluxation in children, whose ligaments are much more elastic than adults. In fact up to 40% of pediatric cervical spines will show a pseudosubluxation, most often at C2-3.
An excellent paper on the subject is available from Loren G. Yamamoto, MD, MPH, U. of Hawaii on the Internet. (www2.hawaii.edu/medicine/pediatrics/pemxray/vlc05.html.) Dr. Yamamoto’s references include the original paper by LE Swischuk in *Radiology* 1977; **122**: 759-763.

Malalignment of C2-3 includes the common causes of pseudosubluxation and hangman’s fracture. In order to resolve this problem, Dr. Swischuk defined a line drawn from the posterior arch of C-1 to the posterior arch of C-3. This line should be within one mm (some people say two mm’s) anterior to the posterior arch of C-2. If it is greater than 2mm, a fracture of the arch of C-2 is likely.

![Figure # 161 (left). The red line represents Swischuk’s line. The line should pass through or be no more than 1-2mm anterior to the posterior arch cortex of C-2 (yellow line). The turquoise lines indicate the position of the posterior arches of C-4 and C-5 so you get some idea of how to locate posterior arch margins. The arch is seen en face causing the denser oval appearance (red arrow).](image1)

Sometimes in neck injuries like whiplash, all that can be seen is a loss of or straightening of the usual lordotic curvature. When the curvature reverses with angulation of the posterior vertebral margin, the injury is more severe and may involve an intervertebral disc or fracture. Frequently these findings can only be seen in an upright lateral view, which in my opinion, should be done if the patient's condition permits and the cross table view shows no abnormality.

![Figure # 162 (left) and # 163 (right). Normal lordotic curve as indicated by the red line in figure 155. Note the loss of lordosis in figure 156 to your right. There is a hangman’s fracture of C-2 (red arrow).](image2)
Since over 25% of cervical fractures involve C-1 C-2, it is good practice to include a coned down view of the odontoid in the a-p projection. ER personnel and trauma surgeons are familiar with the odontoid view, but should be aware of a couple of projection artifacts which are often interpreted as fractures. One is due to the gap between the two frontal maxillary incisors causing a vertically oriented pseudofracture. The inferior edge of these same incisors or sometimes the posterior arch of C-1 can also simulate a transverse fracture at the base of the odontoid.

The odontoid view also gives you a good look at the alanto-atlas articulation and normal spacings. You will quickly learn to recognize anything out of the ordinary. Compare the normal odontoid view above with figure 167 on the next page and see if you can spot the abnormality before reading the answer.
Figure #167 (left). Open mouth odontoid view of a trauma patient. Can you spot the abnormality? Clue: how do the lateral margins line up?

Figure #168 (right). Note the lateral edges of C-1, the atlas, (red arrows) are lateral to the edges of C-2, the axis, white arrows). In addition there is a wide gap between the lateral masses of C-1 (blue arrow). This patient has a classical Jefferson fracture of the atlas. See lateral view next image.

Figure #169 (left). Small white arrow points to a Jefferson fracture of the atlas. Did you note the ET tube?
The spinous and transverse processes should also be carefully scrutinized during your alignment evaluation. In addition to the alignments look for fractures or defects. Failure of the posterior arch to fuse is a common congenital defect representing spina bifida occulta as shown in previous figures, but complete absence of the posterior spinous process or complete failure of the posterior arch to fuse can occur anywhere in the spine.

Don't be fooled by the Os ligamentum nuchae, a normal sesmoid in the neck, as shown in figure 171.

Figure # 170 (left). White arrows indicate another case of spina bifida occulta, this time involving two levels at the cervical dorsal junction (C-7 and T-1).

Figure # 171 (right) negative radiograph. Red arrow points to an os ligamentum nuchae which is a normal sesmoid sometimes seen in the neck. The position of the os nuchae in this case might be mistaken for an avulsion fracture of the posterior spinous process.

Figure # 172 (above). Small black arrow shows an un-united apophysis which can also be mistaken for a fracture.
Radiologists also look at all the information on the film, which includes the soft tissues. You don't want to miss a large aneurysm or other gross finding just because you were zeroed in on the bones! See if you can spot the soft tissue abnormalities in the following illustrations.

**Figure # 173 (left).** Can you spot the soft tissue abnormality in the radiograph to your left? Answer on the next page.

**Figure # 174 (right).** Ignoring the vertebrae which are not very well reproduced on this image, scrutinize the soft tissues for a specific abnormality and diagnosis. See next page for answer.
Figure # 175 (left) and #176 (right). The red arrow on the left shows a normal distance from the airway to the anterior vertebral line. The blue arrow shows displacement of the airway anteriorly by a retropharyngeal mass in this case representing an abscess.

Figure # 177 (left) and # 178 (right). The blue arrows show the outline of a normal epiglottis contrasted by air in the hypopharynx. The red arrows show the “thumb-like” swelling of the epiglottis in a patient with acute epiglottitis, a medical emergency.
Finally, the spine gives rise to a couple of Aunt Minnies besides the limbus vertebrae and Schmorl's nodes mentioned previously.

**Figure # 179 (left).** Besides the obvious narrowed disc (blue arrow) associated with eburnation (whitening) of the vertebral margins and reactive bone anteriorly (red arrows), there is also other (soft tissue) abnormality. What do you see?

**Figure # 180 (right).** Did you spot the calcifications in the abdominal aorta (white arrows)? These show a normal caliber aorta opposite L-4, however it is not unusual to see an aneurysm. Any aneurysm over 4cm in diameter is likely significant. By the way, did you make a diagnosis of discitis in this case? It’s very suspicious!
Figure # 181 (left). The vertically oriented trabeculae (red arrows) in this lateral view of a vertebral column have been likened to Yankee pin stripes. The appearance is an “Aunt Minnie” for vertebral hemangioma. Film courtesy of the X Ray Files www.radiology.co.uk xrayfile/xray/cases/3/3-005/q.htm. Credit Scottish Radiological Society. Thanks to Dr. Andrew Downie.

Figure # 182 (right) The most outstanding feature of ankylosing spondylitis (Marie-Strumpell disease) is the ossification of the spinal ligaments. The anterior longitudinal ligaments are affected first as shown here (white arrows). The appearance is an “Aunt Minnie” for this disease.
A final review, then, for reading the spine is:

1-HEIGHTS OF THE VERTEBRAL BODIES AND INTERSPACES
2-BONE DENSITY
3-FACETS (the Scotty dog)
4-NEUROFORAMINA
5-ALIGNMENTS
   facets
   margins
   spinous and transverse processes
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