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Review Article

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DIAGNOSIS AND COMMON DIFFERENTIAL DIAGNOSIS OFOSTEOPOROTIC VERTEBRAL FRACTURES

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INTRODUCTION

The characteristics of osteoporosis are a decrease in bone mass and degradation of bone microstructure, leading to bone fragility and an increased risk of fractures. Osteoporotic vertebral fracture (OVF) is the most common type of osteoporotic fracture. In addition to bone density, imaging evaluation of vertebral fracture (VF) can predict further fracture risk in elderly individuals. OVF can be seen as an early marker for other more severe fractures, such as hip fractures. Some guidelines recommend spinal imaging as a screening tool for osteoporosis. The focus of this article is on the prevalence of OVF detected during physical examination screening in elderly women, rather than traumatic vertebral fractures occurring in patients with osteoporosis.

Diagnosis and classification criteria for osteoporotic vertebral fractures

OVF can be divided into two categories: 1. OVF without clear trauma; OVF after low-energy trauma events (although some patients may not remember the trauma event). Traumatic OVF can resemble high-energy traumatic fractures in patients with osteoporosis in appearance, while for truly non traumatic OVF, fractures or vertebral deformation can be a slow progression process. From this perspective, there may be no clear boundary between elderly women without OVF and those with "mild" OVF, such as mild endplate depression, which is common in spinal CT scans of elderly women. The simple quantitative measurement of OVF is time-consuming and cannot provide differential diagnosis.[1] The measurement results depend on the placement of measurement points, and the presence of lip like protrusions at the posterior edge of the vertebral body affects the measurement results, so it is currently less commonly used. In the early 1990s, GENENT and colleagues at the University of California, San Francisco proposed a semi quantitative (SQ) grading scheme to evaluate OVF[2] (Table 1), which is currently more commonly used. However, it is difficult for general doctors to apply the SQ standard solely by reading text descriptions such as GENENT. For example, DIACHINTI et al.[3] A study was reported, in which 102 out of 562 cases of OVF identified by radiologists in peripheral hospitals were classified as normal vertebral bodies by experienced radiologists in the central hospital, despite the application of photography techniques and standardization of film interpretation; And 205 cases of OVF were erroneously assessed as (false) negative by radiologists from surrounding hospitals. The GENENT SQ method relies on visual estimation of vertebral body height Row classification is another reason for poor consistency among reviewers. The author also noticed a trend that visual estimation results tend to overestimate the severity of vertebral height decline compared to measurement results.[4] According to GENENT's description[2], mild OVF requires a height loss of ≥ 20%. This can lead to some confusion, such as whether a 15% compression of vertebral height deformation meets the criteria for OVF diagnosis. However, in reality, vertebral deformation that has not reached a height reduction of 20% is often classified as SQ level 1 OVF by colleagues at the University of California, San Francisco.[5] Because if the threshold for OVF is strictly followed as ≥ 20% decrease in vertebral height, some clinically significant OVFs with a decrease in vertebral height of<20% will be overlooked in practice. If SQ standards need to be followed for epidemiological research purposes, the author suggests that mild OVF include OVF with ≥ 10% to 25% vertebral height reduction.

Based on GENENT's initial SQ criteria, the author proposes an improved version of semi quantitative criteria (mSQ) grading for clinical evaluation of OVF in elderly women[6] (Table 1). When using mSQ, as long as a qualitative diagnosis of OVF can be made, the requirement of 20% vertebral height reduction at mild levels is eliminated. Not requiring a certain degree of vertebral height reduction may redirect the diagnostic doctor's attention towards actual fracture deformation. The author suggests categorizing the OVF with a high decrease of 20% to 34% as a single moderate level. This mSQ scheme can be more convenient to implement, for example, if the naked eye estimates a decrease in vertebral height by more than one-third, the OVF is severe (about>34%), while a decrease in vertebral height by less than one- fifth is mild (<20%).

In addition, for the purpose of research and to better record OVF and facilitate comparison between different studies, the author proposed the extended version of semi quantitative criteria (eSQ)[4] (Table 1). To avoid inconsistent estimates of vertebral height decline by different doctors, eSQ uses the height of adjacent normal vertebral bodies as a reference and evaluates vertebral height decline through measurement. The original SQ was moderately divided into two levels, as OVF with a height decrease of ≥ 1/3 always showed cortical fractures of the endplate on plain films, and these patients were more likely to have multiple OVFs.[7,9] Subdivision of SQ severity helps to record the progression of severe OVF (for example, a 45% decrease in OVF progression to a 75% increase in OVF progression.

Table 1: Genant semi quantitative (SQ) grading and modified and expanded semiquantitative grading (mSQ, eSQ) criteria for vertebral height reduction.

classification : The degree of decrease in vertebral height

<1/5 @ ≥ 1/5~1/4>1/4~1/3>1/3~2/5>2/5~2/3>2/3

Genant SQ # 0.5 mild improved SQ (mSQ) mildsevere
moderate

Extended SQ (eSQ) with mild to moderate to severe collapsemoderate
severe

collapse

Note: Vertebrates with normal imaging morphology are classified as Grade 0# The SQ classification based on the degree of vertebral height decline is not suitable for acute or subacute fractures@ Diagnosis relies on a clear fracture like vertebral body shape change (considering the shape of adjacent vertebrae compared to their expected shape).

Descend

Flexible eSQ methods can also be applied in epidemic research. For example, researchers can decide that mild OVF should have a decrease in vertebral body height of ≥ 10%, or a combination of ≥ 20% to 1/3 vertebral body height decreases into one level, or they can still choose to calculate only those OVFs with a decrease in vertebral body height of ≥ 20% (referred to as apparent OVF). Although it may not be necessary for highly experienced doctors to measure each OVF, the author believes that in scientific research, the grading of vertebral height decline should be based on measurement rather than visual estimation. The severity description of OVF in this article is graded according to eSQ.

The main limitation of GENENT SQ, mSQ, and eSQ grading is to classify the severity of OVF solely based on the decrease in vertebral height. These classifications are more suitable for OVF that is non-invasive or caused by minor trauma. If OVF is caused by trauma within the defined range of low-energy trauma, the degree of decrease in vertebral height will be influenced by both trauma energy and bone strength. Among the general elderly women without a history of physical labor, OVF caused by trauma or mild trauma may be more common. Moreover, as OVF can repair[9], the decrease in vertebral height may partially or completely recover. The degree of vertebral height reduction may be a late consequence of low-energy traumatic OVF. Therefore, for OVF detected during physical examination, the degree of vertebral height loss and the number of OVFs in the subjects may still be reasonable indicators for evaluating spinal strength. In elderly subjects, some OVFs may maintain their severity for a long time due to repair and healing processes, meaning that if they are not repaired and healed, their severity will gradually progress. However, the GENENT SQ standard is not applicable to scenarios of acute/subacute trauma. For the classification of traumatic OVF in acute or subacute phases, other criteria may be more appropriate.[10,12] The application of SQ standards in back pain outpatient patients may also have potential issues, as some back pain outpatient patients suffer from acute/subacute low-energy vertebral fractures. For these patients, careful analysis of cortical fractures of the endplate is crucial.[13,14]

(Figure 1, Figure 2).

Figure 1: Spinal imaging of elderly women with a recent history of low-energy trauma. A. shows a concave endplate, anterior cortical flexion, and slight decrease in vertebral height on the L2 vertebral body (arrow); B. Magnetic resonance imaging (T2 weighted fat suppression image) shows L2 End plate depression and bone marrow edema (arrow).

Figure 2: After low-energy spinal trauma in elderly women, A. Spinal plain film shows T7 vertebral endplate fracture in an upright position (arrow); B. Spinal plain film lateral view shows T7 vertebral endplate fracture (arrow).

Evidence based diagnosis of osteoporotic vertebral fractures

According to the definition of osteoporotic fractures, when low-energy trauma induces acute VF, imaging, especially T2 weighted magnetic resonance imaging, can clearly diagnose OVF (Figure 1). In addition, there is no gold standard for distinguishing OVF from non osteoporotic vertebral fractures in every case. In severe vertebral fractures or vertebral collapse, higher accuracy can often be achieved Qualitative diagnosis of OVF; For milder cases, the diagnosis of a vertebral fracture as OVF on plain film is based on probability rather than absolute diagnosis. This probability depends on many factors (including the gender and age of the subjects), such as vertebral deformation with concave or double concave endplates, and a higher probability indicated by older women, while vertebral compression in manual labor males is more likely to be non osteoporotic compression deformities.[15] According to the classification of OVF diagnosis described earlier, although the diagnosis of severe or some moderate OVF is generally not a problem in elderly women, the following three questions need to be clarified for mild osteoporotic vertebral fracture like deformation: are these really fractures? Is it osteoporosis? Does mild OVF have clinical significance? The following three studies answer these questions.

In a study of elderly women[16], 27 cases with 38 vertebral surfacesIt is now anterior wedge-shaped, with a height decrease of<20%. X-ray images do not indicate endplate depression, while CT scans of 28 vertebrae (73.7%) show endplate depression, indicating a fracture and possible osteoporosis (Figure 3). Therefore, the vertebral wedge compression in elderly women is statistically more likely to be OVF.

Retrospective analysis of vertebral deformation on lateral chest X-rays of 408 female and 374 male patients (Jiaxing study).[15] These patients underwent lateral chest X- rays due to mild symptoms (such as fever, cough, etc.) or routine health examinations,but had no history of spinal or metabolic diseases. Fractured vertebral deformities (FSVDs) are defined as vertebral deformations that cannot be distinguished from vertebral fractures on a radiological level. In the age groups of ≤ 20 years old,>20-34 years old,>34-45 years old, and ≥ 45 years old (females 45-59 years old, average 50.2 years old; males 45-67 years old, average 54.1 years old), the detection rates of FSVD in females were 13.4%, 8.3%, 11.8%, and 25.8%, respectively, and the detection rates of FSVD in males were 29.3%, 26%, 34.3%, and 44.8%, respectively. For cases ≤ 34 years old, 5 male cases detected ≥ mild FSVD (vertebral height loss ≥ 20%). In the age group of 35-44, 2.0% of women and 2.9% of men experience vertebral deformation and endplate depression. The cause of these FSVDs may be stress related microfractures, and FSVDs can repair and heal. Mild vertebral wedges in young and middle-aged individuals (<45 years old) are likely to have no clinical significance. The FSVD in these 21-44 year old male and female populations can represent the baseline noise for OVF assessment in the elderly.

For mild OLVF (osteoporotic like vertebral fracture, vertebral height loss<20%), follow-up showed that elderly female participants with mild OLVF had a higher risk of further vertebral fractures than those without baseline OVLF, and had lower bone density than those without baseline OVLF.[8,9] However, statistically speaking, elderly male participants with mild OLVF had no higher risk of further VF than those without baseline OVLF, and there was no difference in bone density between the two groups. Therefore, mild OLVF has clinical significance at the statistical level in elderly women (i.e. not necessarily every patient has clinical significance), but it has no clinical significance at the statistical level in elderly men.

Based on the above discussion, it is recommended to use the term OLVF for at least mild cases in elderly women and mild to moderate cases in elderly men when screening for fracture like vertebral body deformation in elderly subjects through X- ray examination.

Osteoporosis like vertebral fractures replace OVF, as it is often not possible to accurately diagnose these vertebral deformations as OVF based solely on spinal X-ray images. On the other hand, the term FSVD can be used for fracture like vertebral deformation in middle-aged and young subjects, which is generally caused by micro fractures and has no clinical significance.

Morphology of osteoporotic vertebral fractures

OVF is common in the thoracolumbar (most common) and mid thoracic segments, while T1~3 and L5 are relatively rare but can also occur sporadically. In vertebral osteoporosis, Due to the loss of bone trabecular support and thinning of the endplate itself, the endplate becomes weaker. End plate fractures are very common in OVF and may be a crucial link in the development of OVF.[11,13,17] However, due to its resolution and projection coverage, flat film is not a sensitive method for detecting endplate depression.[16] Although typical OVFs involve vertebral body double concavity and endplate concavity, atypical OVFs can have various shapes (Figures 1 to 4). OVF on flat films can also appear as a simple wedge without endplate depression (Figure 3). On the other hand, in the absence of high-energy trauma, endplate depression (or endplate fracture) can also occur in individuals with normal bone strength.[15] Therefore, endplate fractures or vertebral dimple deformation are not characteristic manifestations of OVF, but rather increase the probability that vertebral deformation is osteoporotic. After excluding common differential diagnosis of OVF, a single vertebral wedge in elderly women is likely to be osteoporotic.[18]

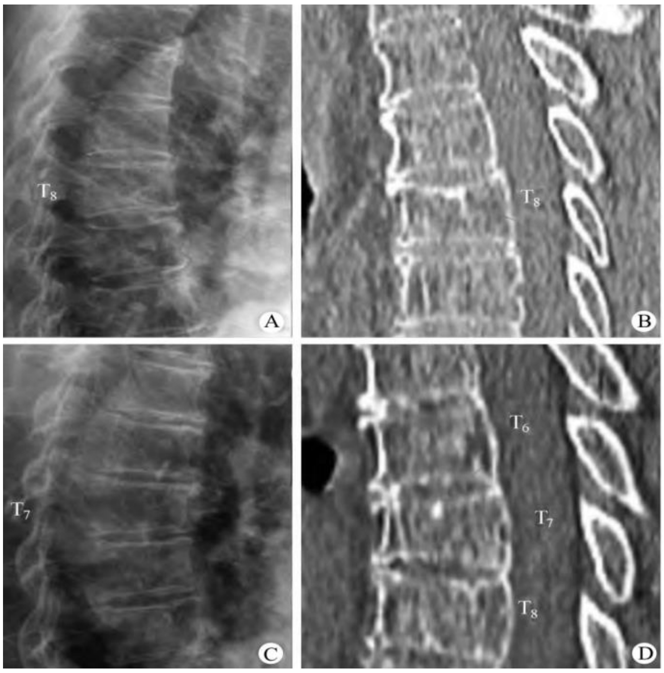

Figure 3: Chest imaging findings of two elderly women (A and B represent one) Patient (C and D are another patient) A. X-ray plain film shows T8 vertebral absence Slight wedge-shaped with clear endplate depression; B. CT shows T8 height descent and brightness Visible upper endplate depression (arrow); C. The X-ray plain film shows that there is no T7 vertebral body Clearly identify mild wedges in the endplate depression; D. CT shows a significant decrease in T7 height[5] The upper endplate is concave (arrow).

Diagnosing osteoporosis based on osteoporotic vertebral fractures

The author proposed the concept of diagnosing osteoporosis based on imaging OVF.[19] On spinal imaging, evaluate T4-L5 spine according to eSQ. Each vertebral body is divided into no OLVF or OLVF combined with<20%, ≥ 20%~25%,>25%~1/3,>1/3~40%,>40%~2/3, and>2/3 vertebral height reduction, and assigned scores of 0, -0.5, -1, -1.5, -2, -2.5, or -3, respectively. If there are two adjacent lightMicro OVLF, score -0.5, if there are three adjacent mild OVLF, score -1. The evaluation of vertebral height reduction should be as accurate as possible, and the degree of vertebral height reduction should be evaluated by comparing it with adjacent vertebral bodies.[4] Then add up the scores of T4 to L5, and the total score is called OLVFss (OLVF sum score). Spinal lateral plain films T1~3 often show poor results, and OVF at T1~3 levels is rare. However, if OLVF is seen at T1~3 levels, they are also included in the OLVFss calculation. In females, an OVFss ≤ -1 meets the criteria for the lowest T-value of ≤ -2.5 in the femoral neck, lumbar spine, and hip, indicating osteoporosis, while an OVFss ≤ -1.5 meets the criteria for diagnosing osteoporosis with a femoral neck T-value ≤ -2.5.[19] Two non adjacent mild OLVF or a single mild OLVF indicate osteoporosis, while three non adjacent mild OLVF, one mild OLVF and one mild OVF, or one OLVF with a significant decrease of>25%(>moderate level), can meet the diagnosis of female osteoporosis. When taking a lateral chest X-ray, it is also possible to evaluate whether there is OLVF in the T4 to L2 (or L1) vertebrae. Similarly, if a lateral chest X-ray shows 3 mild OVLF or 1 OVF ≥ moderate, it is considered a diagnosis of osteoporosis.

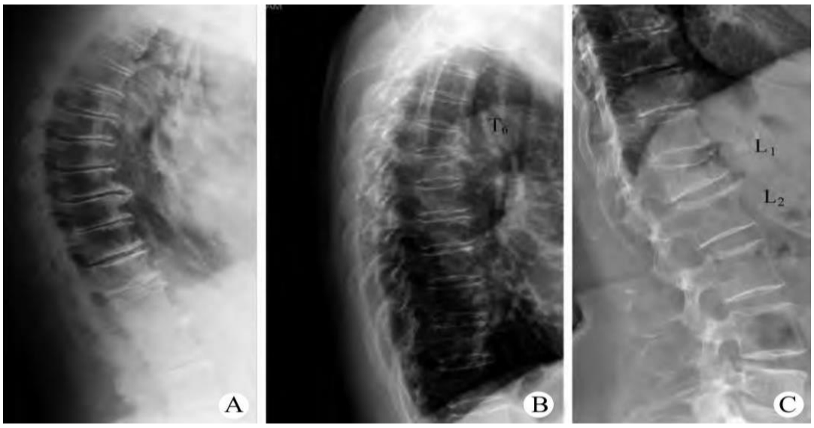

Figure 4: Osteoarthritis Wedge Changes and Osteoporosis Fractures in Elderly Women A. Spinal X-ray plain film, showing anterior wedges of multiple vertebrae in the mid thoracic segment, with similar appearances of each involved vertebra, and narrowing of intervertebral disc space and osteophyte proliferation, but no endplate depression; B. The lateral chest X-ray shows significant deformities in the T6 vertebrae of the spine, which is consistent with the manifestation of osteoporotic fractures; C. Spinal X-ray plain film shows obvious deformity in L1, consistent with the manifestation of osteoporotic fracture, while L2 shows upper endplate depression (i.e. endplate fracture).[5]

There is still controversy over how to diagnose prevalent OVF in elderly men. The incidence of OVF in elderly men is half of that in age matched elderly women.[20,21] Therefore, the appropriate diagnostic criteria for radiological OVF should make the incidence rate of imaging OVF in elderly men half that of age matched elderly women.

The research results of the author in Jiaxing show that OLVFss ≤ -2.5 is relatively rare in males, but OVFss ≤ -2.5 can occasionally be seen in males with normal bone strength. Therefore, an OLVFss of -2.5 cannot determine the diagnosis of male osteoporosis based on imaging, and these results highlight the diagnosis of osteoporotic vertebral fractures in elderly Chinese men.

The difficulty of breaking. In the United States, the incidence of hip fractures in Asian males is lower than that in African Americans.[22,23]

Differential diagnosis of osteoporotic vertebral fractures

The most important differential diagnosis of OVF is malignant vertebral deformation(metastatic bone disease, multiple myeloma, etc.) and vertebral deformation caused by some hematological diseases. The imaging differential diagnosis between OVF and tumor vertebral deformation is sometimes easy, but sometimes it is not possible to rely on plain films and requires further imaging, such as MRI examination.[14]

Generally speaking, OVF most commonly affects the thoracolumbar and mid thoracic segments, with typical OVF typically exhibiting endplate compression or anterior wedge deformation. Careful analysis of radiological morphology in most cases.

It is possible to correctly distinguish OVF from tumor vertebral deformation based on plain films. The deformation of the old vertebral body caused by high-energy trauma is not uncommon,

But it is much less common than scoliosis or X-ray oblique projection pseudo deformation. In addition, both low-energy vertebral fractures and high-energy vertebral fractures may occur in patients with osteoporosis, and a history of high- energy trauma is important for diagnosis. When involving obvious low-energy traumatic events, the appearance of some OVFs may be similar to that of traumatic VF (Figure 2). At the individual subject level, vertebral deformation caused by OVF and old high-energy trauma may not always be absolutely distinguishable through plain film examination. The most common differential diagnosis of OVF includes scoliosis, X-ray oblique projection pseudodeformation, and osteoarthritis (including acquired short vertebrae and osteoarthritis wedge-shaped degeneration). Scoliosis and X-ray oblique projection pseudodeformation are the most common causes of differential diagnosis of OVF. If both frontal and lateral plain films are taken at the same time, the comparison of frontal and lateral film readings can solve these problems. On lateral plain films, the OVF at the junction of the thoracic and thoracolumbar segments usually shows varying degrees of anterior vertebral height reduction, while the anterior vertebral height remains unchanged due to pseudo deformation caused by scoliosis and X-ray projection, and the endplate rings of these pseudo deformations often exhibit elliptical projections (Figures 5 and 6). In the lumbar spine, an OVF with a concave endplate can also be seen without a decrease in anterior vertebral height. The estimation of vertebral height decline and the severity grading of OVF can depend on the degree of deviation of the vertebral body from the center of the X-ray beam focus. Special attention should be paid to the evaluation of vertebral bodies that deviate from the center of the X-ray beam focus (Figure 7).

Acquired short vertebrae (aSV, corresponding to congenital short vertebrae) often show endplate depression on CT during a single episode, therefore it is mostly OVF.[16] However, multiple aSVs did not show CT endplate depression, but instead showed the highest reactive density in the endplate, which is related to degeneration (Figure 8). Therefore, when diagnosing aSV, it is necessary to have at least two adjacent aSVs in the same subject (otherwise it is more likely to be OVF). Multiple aSVs are associated with physical labor such as weight-bearing, and there is no strong correlation between aSVs and an increased risk of fractures in other vertebrae.[9] The difference between multiple adjacent aSVs and multiple adjacent OVFs is that multiple vertebral bodies in multiple aSVs have similar appearances, while in multiple OVFs, different OVFs typically exhibit different shapes and severity levels (Figure 8). Osteoarthritis wedge-shaped transformation does not further increase the risk of osteoporotic fractures. Degenerative wedge-shaped degeneration usually involvessimilar deformations of multiple adjacent vertebrae, often accompanied by intervertebral disc stenosis and osteophytes (Figure 4). Of course, sometimes degenerative changes and OVF may occur Same vertebral body.

Figure 5: Scoliosis of elderly women A. Lateral X-ray shows L3 presenting as a pseudo fracture, with the anteriorheight of L3 remaining largely unchanged [5]; B. The anteroposterior X-ray shows lumbar scoliosis, but the lumbar spine has a normal shape.

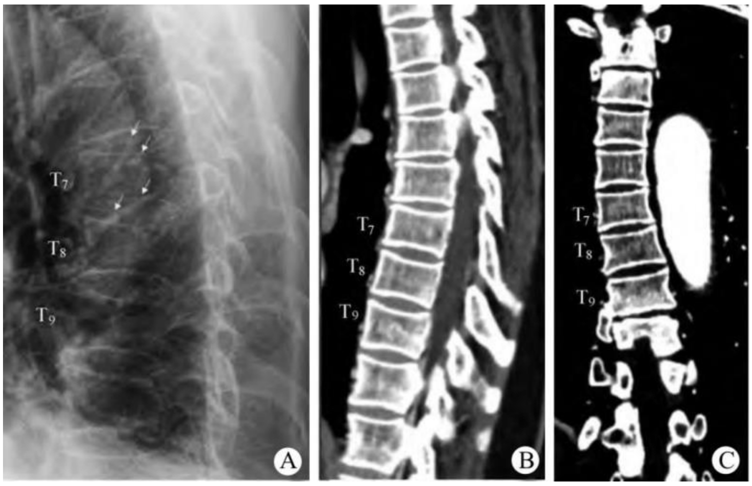

Figure 6: Chest imaging of elderly women. A. Lateral plain film shows concave upper and lower endplates of T7, T8, and T9 vertebrae. The projection of the endplate ring is a clear elliptical shape (arrow), indicating the rotation of the vertebrae relative to the X-ray beam. The anterior height of the T7-9 vertebral bodies remains unchanged.[16] B. Reconstruct sagittal CT images; C. Coronary CT images; Display slight scoliosis of T6-9 vertebrae (facingto the right), and no significant deformation of T7-9 vertebrae.

Figure 7: X-ray projection of elderly women has a significant impact on the appearance display of the vertebral body. A. The upper endplate of T11 is normal; B. T11 endplate depression performance; The degree of decrease in L2 vertebral height in A seems to be more severe than in B, with L2 in A deviating more from the center of the X- ray beam focus than in B.[5]

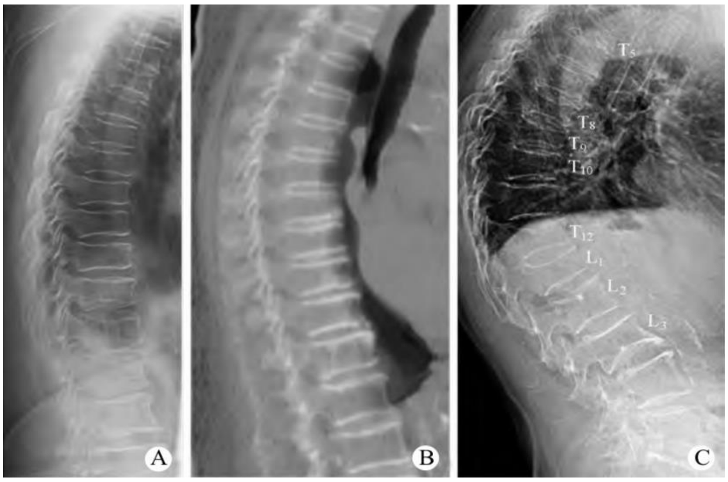

Figure 8: Differential diagnosis of multiple acquired short vertebrae and multiple osteoporotic vertebral fractures in elderly women A. Plain film showing multiple short vertebrae; B. Sagittal reconstruction CT shows multiple low vertebrae; C. Flat film displays multiple OVFs. In C, there is a significant difference in the shape and severity of OVF, with most showing a concave endplate. * on L2 represents upper endplate fracture (depression); Expansion endplate displayed on L3 (Developmental variation). In A and B, there is not much difference in the shape and severity of multiple dwarf vertebrae, and the dwarf vertebrae do not show obvious wedge-shaped or endplate depression. In B, an increase in density of the relevant endplates indicates inflammatory changes.[9]

SUMMARY

For most mild and mild levels of vertebral compression, plain films can only diagnose OVF with statistical probability. But experienced doctors can mostly diagnose severe and collapse grade fracture like changes as OVF. Build.

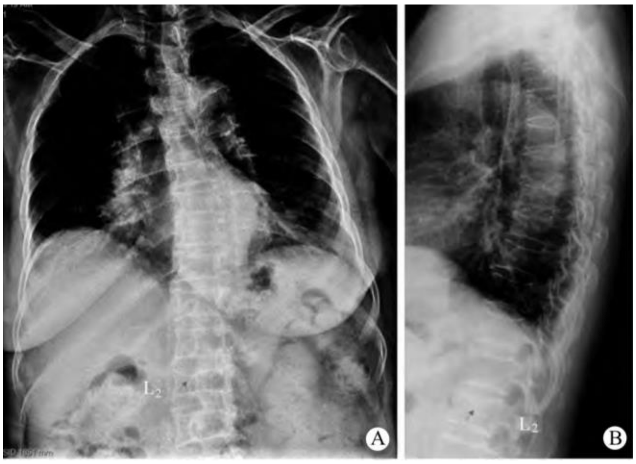

Figure 9: X-ray chest X-ray of a 73 year old woman A. Visible on the chest X-ray in the upright positionL2 vertebral deformation (arrow); B. Lateral view shows L2 compression fracture with upper endplate fracture.[24]

Men and women are advised to use different thresholds for diagnosing OVF, with a higher threshold for male patients to diagnose OVF. The most important differential diagnosis of OVF is vertebral deformation caused by tumor (metastatic bone disease, multiple myeloma, etc.) and vertebral deformation caused by certain hematological diseases. The most common differential diagnoses of OVF include oblique X-ray projection, scoliosis, acquired dwarfism, and osteoarthritic vertebral wedge.

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