

Position Statement

Vertebral Fracture Assessment: The 2007 ISCD Official Positions

**John T. Schousboe,^{*,1,2,a} Tamara Vokes,^{3,b} Susan B. Broy,^{4,b} Lynne Ferrar,^{5,b}
Fergus McKiernan,^{6,b} Christian Roux,^{7,b} and Neil Binkley^{8,c}**

¹Park Nicollet Health Services, Minneapolis, MN, USA; ²Division of Health Policy and Management, School of Public Health, University of Minnesota, Minneapolis, MN, USA; ³Division of Endocrinology, University of Chicago, Chicago, IL, USA; ⁴Illinois Bone and Joint Institute, Park Ridge, IL, USA; ⁵University of Sheffield, Sheffield, UK; ⁶Center for Bone Diseases, Marshfield Clinic, Marshfield, WI, USA; ⁷Publique-Hôpitaux de Paris, Université Paris-Descartes, Hôpital Cochin, Paris, France; and ⁸University of Wisconsin, Madison, WI, USA

Abstract

Vertebral fracture assessment (VFA) is an established, low radiation method for detection of prevalent vertebral fractures. Vertebral fractures are usually not recognized clinically at the time of their occurrence, but their presence indicates a substantial risk for subsequent fractures independent of bone mineral density. Significant evidence supporting VFA use for many post-menopausal women and older men has accumulated since the last ISCD Official Position Statement on VFA was published. The International Society for Clinical Densitometry considered the following issues at the 2007 Position Development Conference: (1) What are appropriate indications for Vertebral Fracture Assessment; (2) What is the most appropriate method of vertebral fracture detection with VFA; (3) What is the sensitivity and specificity for detection of vertebral fractures with this method; (4) When should additional spine imaging be performed following a VFA; and (5) What are the reporting obligations for those interpreting VFA images?

Key Words: Dual-energy X-ray absorptiometry; fracture; guideline; imaging; position; vertebral fracture assessment.

Introduction

Vertebral fractures are common, and their incidence increases substantially in women and men with increasing age. Population-based studies in North America (1–4), Europe (5–7), Australia (8), and Asia (9–13), indicate a radiographic vertebral fracture prevalence ranging from 10% to 26% in both men and women age 50 and older, depending on the specific population and definition of vertebral fracture

employed. If only moderate or severe vertebral fractures are considered, the prevalence in these populations ranges from 5% to 15%. The prevalence rises from 2% to 10% in both sexes for those aged 50 to 60, to 50% or more among women age 80 and older (1,2,5).

Similar to prior fractures at other skeletal sites, prevalent vertebral fractures predict incident non-spine fractures (14–20), independent of bone mineral density (BMD) and other fracture risk factors (15,21). Prevalent vertebral fractures are more powerfully predictive of incident vertebral fractures than fractures at other skeletal sites (20,22,23), conferring a four-fold risk independent of BMD and other fracture predictors (15,24). Even vertebral fractures that do not come to clinical attention (25,26), cause more morbidity than once recognized (25,27). The presence or absence of prevalent vertebral fracture, therefore, can have a substantial influence on estimate of incident fracture risk and consequent

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*Address correspondence to: John T. Schousboe, MD, MS, Park Nicollet Health Services, 3800 Park Nicollet Blvd., Minneapolis, MN 55416. E-mail: john.schousboe@parknicollet.com

^aTask Force Chair.

^bTask Force Member.

^cISCD PDC Liaison.

morbidity, and should influence the decision as to how aggressively to pursue pharmacologic therapies to reduce fracture risk.

Thoracic and lumbar fractures are unique in that the majority of them are not clinically recognized at the time of their occurrence (2,28,29), in contrast to fractures at other skeletal sites. Spinal imaging is therefore required for clinical recognition of vertebral fractures. The quality of spine images obtained with dual-energy X-ray absorptiometry (DXA) has progressed since its introduction in 1987, so that it is now possible to recognize radiographic prevalent vertebral fractures using low-intensity single or dual-energy X-rays on central densitometers (30–43). This offers the opportunity to conveniently incorporate documentation of vertebral fracture status at the point of bone densitometry service, thereby yielding an enhanced estimate of incident fracture risk beyond that provided by BMD and clinical risk factors alone. Although the use of X-ray absorptiometry to image the lateral spine has been labeled in different ways by different authors and different densitometer manufacturers, the ISCD 2005 Official Positions were to replace all of these labels with the term “Vertebral Fracture Assessment”, or VFA (44).

This document outlines an update of the 2005 ISCD Official Positions regarding Vertebral Fracture Assessment, presenting a critical appraisal of the following issues regarding VFA:

- Appropriate indications for Vertebral Fracture Assessment.
- Most appropriate method of vertebral fracture detection with VFA.
- Sensitivity and specificity for detection of vertebral fractures with this method.
- Additional spine imaging to be performed following a VFA.
- Reporting Obligations for Those Interpreting VFA Images.

It should be noted that although this report specifically addresses vertebral fracture assessment on lateral spine densitometric images, the guidelines within also are applicable to vertebral fracture detection using standard lateral radiographs.

Methodology

The methods used to develop, and grading system applied to the ISCD Official Positions, are presented in the Executive Summary that accompanies this paper. In brief, all positions were rated by the Expert Panel on quality of evidence (good fair, poor, where Good is evidence that includes results from well-designed, well-conducted studies in representative populations; Fair is evidence sufficient to determine effects on outcomes, but the strength of the evidence is limited by the number, quality, or consistency of the individual studies; and Poor is evidence that is insufficient to assess the effects on outcomes because of limited number or power of studies, important flaws in their design or conduct, gaps in the chain of evidence, or information), strength of the recommendation

(A,;B,; or C: where A is a strong recommendation supported by the evidence; B is a recommendation supported by the evidence; and C is a recommendation supported primarily by expert opinion), and applicability (worldwide = W or variable, according to local requirements = L). Necessity was also considered with a response of “necessary” indicating that the indication or procedure is “necessary” due to the health benefits outweighing the risk to such an extent that it must be offered to all patients and the magnitude of the expected benefit is not small.

What are Appropriate Indications for Vertebral Fracture Assessment?

ISCD Official Position

1. Post-menopausal women with low bone mass (osteopenia) by BMD criteria PLUS one of the following:
 - Age greater than or equal to 70 yr.
 - Historical height loss greater than 4 cm (1.6 in).
 - Prospective height loss greater than 2 cm (0.8 in).
 - Self-reported prior vertebral fracture (not previously documented)
 - Two or more of the following:
 - Age 60 to 69 yr.
 - Self-reported prior non-vertebral fracture.
 - Historical height loss of 2 to 4 cm.
 - Chronic systemic diseases associated with increased risk of vertebral fractures (for example, moderate to severe chronic obstructive pulmonary disease (COPD), sero-positive rheumatoid arthritis, Crohn’s disease)
 Grade: Fair-B-W-Necessary
2. Men with low bone mass (osteopenia) by BMD criteria, PLUS one of the following:
 - Age 80 yr or older.
 - Historical height loss greater than 6 cm (2.4 in).
 - Prospective height loss greater than 3 cm (1.2 in).
 - Self-reported vertebral fracture (not previously documented).
 - Two or more of the following:
 - Age 70 to 79 yr.
 - Self-reported prior non-vertebral fracture.
 - Historical height loss of 3 to 6 cm.
 - On pharmacologic androgen deprivation therapy or following orchiectomy.
 - Chronic systemic diseases associated with increased risk of vertebral fractures (for example, moderate to severe COPD, sero-positive rheumatoid arthritis, Crohn’s disease).
 Grade: Fair-C-W
3. Women or men on chronic glucocorticoid therapy (equivalent to 5 mg or more of prednisone daily for 3 mo or longer).
 - Grade: Fair-B-W-Necessary
4. Post-menopausal women or men with osteoporosis by bone density criteria (total hip, femoral neck, or lumbar

spine T-score ≤ -2.5), if documentation of one or more vertebral fractures will alter clinical management.

Grade: Good-C-W-Necessary

Rationale

Candidate indications for VFA were evaluated by the task force with two cardinal criteria in mind; that documentation of a prevalent vertebral fracture on spinal imaging may alter clinical management of that individual, and that there is a reasonable pre-test probability that a prevalent vertebral fracture would be found using VFA.

Central Skeletal Site T-score Between -1.5 and -2.4 Among Post-Menopausal Women. Documentation of a prevalent vertebral fracture is most likely to impact therapy to reduce fracture risk among this subset of women compared to other subsets of the post-menopausal population. Both prevalent and incident vertebral fractures are moderately to strongly associated with bone mineral density; in studies to date, odds ratios of 1.5 to 2.4 have been observed for each standard deviation (SD) decrease in femoral neck, total hip or lumbar spine BMD (45–51). While the prevalence of vertebral fractures is therefore greatest among those with osteoporosis by BMD criteria (central site T-score ≤ -2.5), cross-sectional studies show that about half to a modest majority of post-menopausal women with a prevalent vertebral fracture do not have osteoporosis by BMD criteria measured at the femoral neck (45,50,52–57), and over one-third do not have a T-score ≤ -2.5 at either the spine or hip (49). The prevalence of vertebral deformity on VFA images among post-menopausal women referred for bone densitometry with the lowest T-score at the femoral neck, total hip, or lumbar spine between -1.0 and -2.5 has been noted to be 14% to 18% (34,40). Among 8803 post-menopausal women who were screened for the Fracture Intervention Trial in the early 1990s and who had a femoral neck T-score between -1.6 and -2.4 , 16% were noted to have one or more vertebral deformities consistent with prevalent fracture on lateral spine radiographs (57).

The odds ratios for the presence of one or more prevalent vertebral fractures ranges from 1.4 to 1.8 for each 10 yr increase of age, such that among osteopenic women the majority of those with prevalent vertebral fractures are age 65 and over (47,57–59). At least half to two-thirds of these individuals would be confirmed to have a prevalent vertebral fracture on follow-up radiography, given available estimates of the sensitivity and specificity of VFA for detection of radiographic vertebral fractures (see below). Although the efficacy of pharmacologic drug therapy to reduce non-vertebral fracture among those who do not have a femoral neck T-score ≤ -2.5 is questionable, oral bisphosphonates and raloxifene do reduce the incidence of vertebral fracture in this subset (60–62). For the reduction of incident vertebral fractures alone from drug therapy, a strategy of VFA for this population followed by selective radiography for those with apparent mild or moderate deformities on VFA is cost-effective for U.S. Caucasian women age 60 and older (63). In the

absence of prevalent vertebral fracture or other factors that raise fracture risk independent of BMD, however, anti resorptive drug therapy is *not* cost-effective for post-menopausal women with central skeletal site T-scores > -2.5 (64).

Olenginski et al. have shown how VFA for those who do not have osteoporosis by BMD criteria can identify a significant subset of post-menopausal women at high risk of fracture due to the presence of prevalent vertebral fracture (65). Under a policy of including VFA with bone densitometry for women age 65 and older or those with historical height loss of ≥ 1.5 in, 45% of those referred for bone densitometry had VFA performed. Eleven percent of those who had a VFA had a T-score > -2.0 and had a prevalent vertebral fracture documented; as a result their fracture risk was judged to be high rather than low. The incremental cost of VFA to identify an individual at high risk of fracture for whom drug therapy is indicated was significantly lower than that of bone densitometry itself (65).

Subsets of Those with Osteoporosis. Although vertebral fracture is highly prevalent among both post-menopausal women and men with osteoporosis by BMD criteria, at first glance it would appear that VFA has little role to play in decisions regarding pharmacologic management of these individuals since pharmacologic drug therapy to reduce fracture risk is widely considered to be indicated based on BMD alone (66–71). However, even among those with osteoporosis by BMD criteria, the number and severity of prevalent vertebral fractures is a powerful predictor of incident fractures, and affords significantly greater stratification of incident fracture risk when combined with BMD than does BMD alone (72). As such, documentation of a prevalent vertebral fracture in patients with osteoporosis by BMD criteria may affect clinical management in some circumstances.

Teriparatide vs Anti-Resorptive Drug Therapy. Parathyroid hormone analogues substantially reduce the risk of both vertebral and non-vertebral fractures (73), but at considerably greater expense than currently available anti resorptive agents. Direct comparisons of the efficacy of teriparatide compared to anti-resorptive agents suggest that teriparatide improves bone mineral density, reduces back pain, and reduces incident non-vertebral fractures more than alendronate (74–76). Cost-effectiveness studies have suggested that the incremental gains of fracture reduction with initial teriparatide therapy compared to an anti resorptive agent may be achieved cost-effectively in those with the worst BMD (T-scores ≤ -4.0) if they also have a prevalent vertebral fracture (77). When bisphosphonates cannot be tolerated or are contraindicated, teriparatide may be cost-effective in women with osteoporosis by BMD criteria compared to no drug therapy, but only in those with a prevalent vertebral fracture (78). Teriparatide may be particularly cost-effective in these instances if there has been a recent vertebral fracture (78).

Should Bisphosphonate Therapy be Continued or Discontinued? A major current controversy regarding osteoporosis therapy is how long bisphosphonate agents should be

continued (79). While the Fracture Intervention Long-Term Extension (FLEX) trial suggests that continuation of alendronate beyond 5 yr of therapy is not likely to yield significant incremental fracture reduction benefit compared to no drug therapy (80), those at the highest risk of fracture were excluded from FLEX. Moreover, in the subset of patients in FLEX with a prevalent vertebral fracture, those who continued alendronate had a lower rate of clinical vertebral fracture than those who discontinued therapy. Therefore, VFA can reasonably be expected to aid decisions as to how long bisphosphonate therapy should be continued in a substantial proportion of those with osteoporosis.

Vertebral fractures that have occurred recently confer even greater risk (19,81), but fracture age cannot be ascertained by VFA unless a prior imaging study is available. In randomized placebo controlled trials of oral bisphosphonates among postmenopausal women with prevalent radiographic vertebral fracture, the cumulative incidence for those *on drug therapy* with one or more new vertebral fractures over 3 yr ranged from 5% to 18% (82–85). Hence, if a baseline VFA shows a prevalent vertebral fracture at the start of therapy, there is a reasonable pre-test probability of an incident vertebral fracture within the next 3 to 5 yr. If documentation of a new vertebral fracture would result in a decision to continue or intensify drug therapy, then even for those known to have a prevalent vertebral fracture at the start of the therapy a follow-up VFA may be reasonable. However, further research is needed to delineate how often in clinical practice follow-up VFA studies will reveal findings that plausibly would alter clinical therapeutic decisions.

Encouraging Medication Adherence. Non-adherence to prescribed anti resorptive therapy among those for whom these drugs are indicated is very common (86,87). Forty-five percent to 60% of those prescribed oral bisphosphonates discontinue these medications within 1 yr (87–95), and adherence to raloxifene appears to be no better (93). Non-adherence to these agents is associated with less reduction of bone turnover, lower gains of bone mineral density, and higher risks of fracture (89,96). Personal awareness of bone densitometry results is associated with better persistence with and adherence to anti-resorptive therapy (90,97–99), suggesting that knowledge of being personally at high risk of fracture may be important for adherence. Awareness of a prevalent vertebral fracture, therefore, may be associated with better adherence to fracture-reduction drug therapy *if* that person attributes that fracture to the presence of osteoporosis, and perceives a higher sense of threat from fractures that may occur in the future. Studies to date have yielded conflicting results, however, with some showing that a prior history of fracture is associated with better adherence (90,94,100), and some showing no such association (92). However, two studies that have assessed the association between prior *vertebral* fractures and anti resorptive drug adherence both reported a positive association (93,94). Whether or not patient knowledge of a prevalent vertebral fracture discovered on VFA would influence subsequent adherence to prescribed anti resorptive drug therapy has not been tested. However, for those

patients who are reluctant to undertake or are non-adherent to prescribed fracture reduction drug therapy, performing VFA and highlighting the presence of any prevalent vertebral fractures and the incident fracture risk they confer to increase that patient's awareness of their fracture risk seems reasonable. Clearly, further studies on the effect of documentation of previously unknown prevalent vertebral fractures on adherence to fracture reduction medications are needed, before use of VFA specifically to encourage adherence to prescribed pharmacologic fracture prevention therapy can be recommended.

Height Loss. Height loss is typically conceptualized as the difference between current height and recalled height at age 25 (sometimes referred to as historical height loss, or HHL), or the difference between height measurements recorded at two different times (called prospective height loss, or PHL). In many clinical situations, PHL cannot be adequately assessed because prior height measurements are unavailable or only documented for the previous 2 yr or so. Because of recall bias, HHL is generally considered to be a less reliable indicator of true height loss than PHL. Nonetheless, the relative risk for the presence of one or more prevalent radiographic vertebral fractures in those with an HHL of 4 or more centimeters (cm) compared to those with HHL < 4 cm ranges from 1.8 to 2.8 (47,57,101–104). The association between HHL and prevalent radiographic vertebral fracture may be somewhat weaker in men. In the European Vertebral Osteoporosis Study (EVOS), among men, an HHL of 4 cm or more was associated with an odds ratio of 1.49 for the presence of one or more radiographic vertebral fractures compared to those with HHL < 4 cm (102). Two postal surveys in Australia (105), and Norway (106), respectively, have shown that HHL of 2 cm and 3 cm are associated with a self-reported history of clinical vertebral fracture. In contrast, Siminoski et al. were able to demonstrate a higher prevalence of radiographic vertebral fracture only for those with HHL greater than 6 cm, but the study population was drawn from those referred to a tertiary care osteoporosis clinic, and had a high overall prevalence (42%) of vertebral fracture regardless of height loss (107).

The positive and negative predictive values, respectively, for a prevalent radiographic vertebral fracture being present in those with HHL greater than 4 cm range from 14% to 26%, and 86% or greater in populations that were unselected for osteoporosis or fracture risk (102,103,108). The sensitivity of a 4 cm HHL criterion for those with a prevalent vertebral fracture ranges from 31% to 56% in these three studies. In populations that are pre-selected to be at higher risk of fracture however, the positive predictive value of the 4 cm HHL criterion can be expected to be higher, and the negative predictive value to be lower (107).

The association between HHL and prevalent vertebral deformity consistent with fracture on VFA has also been estimated in two studies. In the smaller of these two studies, there was a trend for greater HHL among those with one or more prevalent deformities on VFA (104). A recent, larger study documented a 20% excess risk of one or more prevalent

deformities being present on VFA for each 1 in (2.5 cm) increase in HHL (58).

Historical height loss has also been shown to be associated with *incident* radiographic (59), and clinical (109), vertebral fractures respectively, with odds ratios of 1.08 and 1.35 per centimeter decrease of height. The association is attenuated, but not eliminated, by adjusting for BMD (59). On the other hand, a *prospective* height loss of 2 cm or more has been shown in two studies, respectively to be associated with a three-fold (110), and 6.4-fold (111), increased risk of incident radiographic fractures having occurred over the interval over which the height loss was recorded.

Prior Fracture. The age- and BMD-adjusted relative risk of one or more *prevalent* vertebral fractures being present in those with compared to those without a history of a prior clinical non-spine fracture vary from 1.3 to 1.8 (47,57,58,112). Among 337 post-menopausal women with prior history of clinical fracture, the prevalence of one or more vertebral deformities on VFA was 42% and 20%, respectively, for the subsets with a lumbar spine T-score ≤ -2.5 or a T-score between -1.0 and -2.4 (113). Similarly, prior non-spine fractures are predictive of *incident* radiographic and clinical vertebral fractures with estimated age- and BMD-adjusted relative risks ranging from 1.4 to 2.0 (59,103,114–116), although in the observational Rotterdam study, prior non-spine fracture was associated with incident radiographic vertebral fracture in men but not women (117).

A prior self-reported history of spine fracture is very strongly associated with prevalent radiographic vertebral fracture (57). Prevalent radiographic vertebral fracture in turn has been shown in many studies to be strongly associated with subsequent fractures, especially incident vertebral fractures, independent of bone mineral density (15,23,24,118,119).

Glucocorticoid Therapy. Oral glucocorticoid therapy has been consistently shown to be strongly associated with risk of vertebral fracture among post-menopausal women and men. The odds ratios for one or more radiographic *prevalent* radiographic vertebral fractures in users versus non-users of chronic glucocorticoid therapy range from 1.44 to 6.2 (120–128). Of those few investigations that have not shown any association between oral glucocorticoid use and prevalent vertebral fracture (129–132), two of them were small, underpowered studies (131,132). One study estimated the odds ratio of prevalent vertebral fracture on VFA in those with COPD on chronic glucocorticoid therapy to be five-fold that of historical controls (133). In most (120,124,127,133–139), but not all (125,140,141), studies, the odds of a prevalent vertebral fracture are significantly correlated with either duration of glucocorticoid therapy or cumulative dose, especially a cumulative dose over 10 g (127).

The *incidence* of both radiographic and clinical vertebral fractures has also been shown consistently to be associated with glucocorticoid use (122,142–147), with one exception (148). While some find vertebral fracture incidence is associated with cumulative dose (142,143), there appears to be a stronger relationship with daily dose (122,146,147). After glucocorticoids

are discontinued, the excess risk of vertebral fracture attributable to glucocorticoids drops rapidly, but can persist to a modest degree for a number of years after discontinuation (144). The length of time that the excess risk persists does appear to be correlated with cumulative dose (144).

Glucocorticoid use confers risk of fracture independent of BMD and age (149), and fractures are more likely to occur at any given level of BMD for those on chronic glucocorticoid therapy compared to those who are glucocorticoid naive (122,150–152). However, among those on glucocorticoids, vertebral fracture prevalence and incidence are still positively associated with age and negatively associated with BMD (122,124,141,153,154). Among populations of chronic glucocorticoid users cared for by subspecialists, vertebral fracture prevalence may be as high as 30% in those less than 60 yr of age, and over 50% among those age 70 or older (127,140,155). Among pre-menopausal female glucocorticoid users, the prevalence of vertebral fractures is lower than in post-menopausal women, ranging from 8.7% (153), to 22% (141), but the association between oral glucocorticoid use and vertebral fracture risk compared to age- and sex-matched controls is as strong as among post-menopausal women (147,156).

Some of the excess fracture risk in populations treated with glucocorticoids is attributable to the underlying disease being treated, and is not all due to glucocorticoid use per se. Rheumatoid arthritis (135), COPD (142), Crohn's disease (145), and ankylosing spondylitis (157), have all been associated with an increased risk of vertebral fracture independent of age and glucocorticoid use.

Men. Age, BMD, height loss, and glucocorticoid use have all been associated with prevalent and incident vertebral fractures in men as in women. However, the association with age may be slightly weaker, with vertebral fracture being more prevalent at younger ages (4,5,8,47,158), and less prevalent at more advanced ages relative to women (4,5,8,47). All but one (158), of these studies however, have assessed prevalent vertebral fracture by quantitative morphometry, and the proportion of morphometric deformities that in fact are non-osteoporotic may be greater in men than in women, particularly at younger ages (54). Similarly, the association of height loss with prevalent vertebral fracture may be weaker in men than in women (47), with a recent study finding a significant increase in vertebral fracture prevalence with VFA only in men with historical height loss >2.5 in (6.4 cm) (159). On the other hand, the association between BMD and prevalent vertebral fracture appears to be as strong in men as in women (8), and prevalent vertebral fractures are as strongly associated with subsequent fractures in men as in women (16,17,20,160). The age-specific incidence of radiographic vertebral fracture for men over age 50 is one-third to one-half that of women (161).

Vertebral fractures may be particularly prevalent among men who have undergone androgen deprivation therapy (ADT) for prostate cancer. Accelerated losses of bone are noted after orchiectomy or with ongoing pharmacologic ADT (162–166). In the largest study to date based on the

SEER-Medicare database, the cumulative incidence of clinical vertebral fractures among men surviving 5 or more years after a diagnosis of prostate cancer, was 3.2% and 1.6% respectively, in men who received ADT therapy following diagnosis compared to those who did not (167). The multivariate-adjusted relative risks of any fracture following 1–4 doses of pharmacologic ADT, ≥ 9 doses of pharmacologic ADT, and orchiectomy respectively, were 1.07, 1.45, and 1.54 compared to men who had no ADT following a diagnosis of prostate cancer (167). Other observational studies based on Medicare (168), and private health insurer claims databases (169), respectively, have estimated multivariate-adjusted relative risks of incident clinical vertebral fracture in those men treated with ADT to be 1.45 and 1.22 compared to men undergoing no ADT following a diagnosis of prostate cancer. The age-adjusted relative risk of incident clinical vertebral fracture due to minor or moderate trauma following orchiectomy for prostate cancer was estimated in a population-based medical records dataset to be 3.85 over a mean follow-up period of 4.6 yr (170). One study has estimated the prevalence of radiographic vertebral fracture among men undergoing pharmacologic ADT for a mean treatment period of 30 mo to be 44%, the majority of whom did not have osteoporosis by BMD criteria (171).

Following a diagnosis of prostate cancer, men will often have imaging to rule out spinal metastases, but may not have subsequent follow-up imaging if their prostate specific antigen test results remain low and they have no other clinical signs of skeletal metastases. Lateral radiography or VFA imaging therefore may yield evidence of previously unrecognized prevalent vertebral fractures after a few years of ADT.

Children. Morphometric vertebral fractures may be relatively common in children with a chronic disease requiring glucocorticoid therapy, or following organ transplantation. In a small group of 32 children referred to a specialty center for management of chronic disease using glucocorticoids, 11 (34%) were found to have evidence of a radiographic vertebral fracture using morphometric criteria (172). Within a second cohort of 62 children with juvenile rheumatoid arthritis treated with glucocorticoids of median cumulative dose of 2.2 g for a median time of 2 yr, six (10%) had one or more prevalent vertebral fractures on lateral radiographs (173). Finally, vertebral fracture may be very common in children following organ transplantation. In a cohort of 162 children following kidney, liver, or heart transplantation, the majority of whom were 12 yr of age or younger, the relative risk of incident vertebral fracture was 61.3 compared to age- and sex-matched controls (174). The absolute annual incidences of radiographic vertebral fractures with or without clinical symptoms respectively, were 5.7% and 2.8%. Further research is needed to better define the subsets of children for whom there is a reasonable pre-test probability of a prevalent vertebral fracture being present on VFA and for whom discovery of that fracture would alter clinical management.

Combinations of Risk Factors as Indications for VFA. Since there is some correlation between the risk factors for prevalent and incident vertebral fractures, the pre-test probabilities

of prevalent vertebral fracture among those with various combinations of these risk factors are not obvious. In the European Prospective Osteoporosis Study (EPOS), Kaptoge et al. derived decision rules to predict the presence of one or more prevalent vertebral fractures on baseline study radiographs for both men and women based on mathematical formulae incorporating age, historical height loss, body weight, and self-reported histories of vertebral or non-vertebral fracture (47). The scores yielded by both sex-specific formulae increase with increasing age, increased historical height loss, decreasing weight, and self-reported prior fractures. For both sexes, increasing scores are associated with higher positive and lower negative predictive values for a prevalent vertebral fracture being present. Bone mineral density was also shown by these authors to significantly improve the prediction of radiographic prevalent vertebral fracture based on receiver operating curve analyses. However, modified decision rules incorporating BMD were not presented by the authors.

Vogt et al. analyzed the multivariate-adjusted associations of multiple risk factors with the presence of one or more prevalent morphometric vertebral fractures on lateral radiographs among the 13,000 post-menopausal women who were screened for entry into the Fracture Intervention Trial (FIT) (57). A summary risk score for prevalent vertebral fracture was derived incorporating age, historical height loss, self-reported diagnosis of osteoporosis and self-reported prior vertebral and non-vertebral fractures. One point was given for age 60–69, two points for those age 70–79, and three points for age ≥ 80 . One point was given for 2–4 cm of HHL, two points for > 4 cm HHL, one point each for a self-reported history of a diagnosis of osteoporosis or prior non-vertebral fracture, and six points for a self-reported history of vertebral fracture. For those with summary scores of one, two, and three, respectively, the prevalence of morphometric vertebral fracture was 7.9%, 11.3%, and 15.6%. Obtaining a VFA for post-menopausal women appears to be cost-effective for women without osteoporosis by bone density criteria if the pre-test probability is 10% or greater (63).

The advantage of the decision rule derived from FIT compared to that derived from European Prospective Osteoporosis Study (EPOS) is that it is simplified by the addition of integers assigned to each risk factor, which eliminates the need for complex calculations. Neither of the sets of decision rules incorporate bone mineral density, and were intended for assisting decisions as to whether or not spine radiographs are indicated to detect prevalent vertebral fracture. Vertebral fracture assessment, in contrast, is performed in conjunction with bone densitometry, and a decision rule as to whether or not a VFA study should also be obtained ideally would incorporate BMD as one of the factors. To the extent that a self-reported diagnosis of osteoporosis correlates with a central skeletal site T-score of -2.5 , the decision rule derived from FIT may be better suited for VFA, with BMD substituted for self-reported osteoporosis (one point for BMD T-score at the femoral neck, total hip, or lumbar spine ≤ -2.5 , 0 for BMD T-score > -2.5).

By both the Vogt criteria and the simplified decision rule of Kaptoge et al. post-menopausal women not on chronic

glucocorticoid therapy who fulfill the criteria on page ninety-three would have a pre-test probability of prevalent vertebral fracture of greater than 10%. Using the Kaptoge formula, the pre-test probability for osteopenic men meeting the criteria listed on page six are likely to have a pre-test probability for prevalent vertebral fracture $> 10\%$, but further studies to confirm this are needed.

The EPOS authors have developed parallel decision rules to assess the pre-test probability of an incident vertebral fracture being present on follow-up radiographs taken a mean 3.8 yr after baseline, based on age, historical height loss, gender, and the number of vertebral fractures documented on baseline radiographs (59). A simplified version of this decision rule does not require a calculator; instead the risk of incident vertebral fracture is determined from tabulated score categories.

Discussion

All of the candidate indications for VFA have been judged by two criteria; that those who have the indication have a reasonable pre-test probability of prevalent vertebral fracture, and that documentation of one or more prevalent vertebral fractures is likely to alter clinical management. For postmenopausal women with osteopenia (central site T-score between -1.5 and -2.4), our criteria are based upon, and strongly supported by, the Vogt criteria. For elderly men with osteopenia, the precise pre-test probability of prevalent vertebral fracture being present for those who meet the indication proposed in this paper remains to be fully established, but by the Kaptoge criteria are likely to be 10% or greater. For those on chronic glucocorticoid therapy or with osteoporosis by bone density criteria, the pre-test probability that a prevalent vertebral fracture is present is highly likely to be greater than 10%, and for many such individuals documentation of one or more prevalent vertebral fractures may influence choice of or duration of pharmacologic fracture prevention therapy.

What is the Most Appropriate Method of Vertebral Fracture Detection With VFA? What is the Sensitivity and Specificity for Detection of Vertebral Fractures with this Method?

ISCD Official Position

- The Genant visual semi-quantitative (SQ) method is the current clinical technique of choice for diagnosing vertebral fractures with VFA.

Grade: Good-B-W-Necessary

Rationale

Unique among all skeletal sites, the majority of vertebral fractures do not come to clinical attention at the time of their occurrence, and hence complete ascertainment of prevalent or incident vertebral fracture requires spinal imaging (29,175). A major challenge in determining who should have diagnostic imaging to detect prevalent or incident vertebral fractures is

that there has been lack of consensus as to precisely what constitutes a vertebral fracture (176,177). Vertebrae that have an appearance consistent with prevalent fracture on VFA images or standard radiographs are generally referred to as *deformities*, a term that implicitly acknowledges that some proportion of “deformities” identified on these images may not truly be vertebral fractures. In the rest of this section, we will employ the term “deformities” as an acknowledgement of the limitations of vertebral fracture detection on VFA images or standard radiographs by any of the methods proposed in the medical literature today. We believe that the methods of prevalent vertebral deformity detection on VFA images should be judged by how well they fulfill four criteria; their sensitivity and specificity for true vertebral fractures; their reliability (generally assessed as inter-observer reliability); concurrent validity; and predictive validity (Table 1). In the following section, we will use association with BMD as a measure of concurrent validity, since true prevalent vertebral fractures are associated with low BMD. We will use association with subsequent incident fractures as a measure of predictive validity.

Criteria for Vertebral Deformity Adjudication on Standard Radiography. Traditionally, vertebral fracture adjudication on standard radiographs has been performed qualitatively, primarily by assessing the vertebral endplates and anterior cortex for breaks or discontinuities. However, incremental reductions or changes of vertebral heights or shape in the absence of clearly visible cortical discontinuity may make the distinction between vertebral deformity and normal vertebrae difficult. Qualitative assessments of vertebral fractures therefore, have poor to fair inter-observer and intra-observer reliability (perhaps because of lack of agreed clear criteria) (178–180), and have been considered to be inappropriate as a method of adjudication of vertebral fractures for research studies, where radiographic vertebral fracture was either the dependent or an important predictor variable.

A plethora of quantitative morphometric methods of detecting vertebral deformities designed to be much more reliable than qualitative fracture adjudication were developed in the 1980s and early 1990s (1,2,181–187). Nearly all of these detect vertebral deformities based on reductions of anterior (H_a) and middle (H_m) heights relative to the posterior height (H_p) within the vertebra, and/or on reductions of these heights relative to corresponding heights of adjacent vertebrae. Most have established norms (means and standard deviations) of these height ratios in population-based samples of adult men and women, and define mild and severe prevalent deformities, respectively, to be those where one or more of these height ratios are more than three and four standard deviations below the expected mean. In contrast, the original method of Melton et al. defined a vertebral deformity as one more of these height ratios (H_a/H_p , H_m/H_p , or $H_p/H_{p\pm 1}$) being less than 0.85, rather than defining prevalent deformity in terms of the distribution of these height ratios. Two other groups advocated defining a vertebral deformity as one or more of the three vertebral heights (H_a , H_m , or H_p , rather

Table 1
Comparison of Selected Vertebral Fracture Definitions

Vertebral fracture definition	Concurrent validity ^a (references)	Predictive content validity ^b (references)	Reliability	Useful in clinical practice ^a
Black/SOF	++ ^(9,190)	+++ ^(15,21,190)	+ ⁽¹⁹¹⁾	—
Melton	+ ⁽¹⁾	+ ⁽¹⁴⁾	+ ⁽¹⁸⁸⁾	—
Eastell	+++ ^(8,187,190)	+ ⁽¹⁹⁰⁾	+++ ^(31,32,37,188)	—
McCloskey	+++ ^(6,54,190)	++ ^(51,190)	++ ^(37,188)	—
Ross	++ ⁽⁵¹⁾	++ ⁽²⁴⁾	—	—
SQ (Genant)	+++ ^(190,195,196)	+++ ^(23,118,190)	+++ ^(188,189,194,227)	++
Minne	—	—	+++ ^(184,188,228)	—
Kleerekoper	—	—	+ ⁽²²⁹⁾	±
ABQ	+++ ^(202–204)	—	+ ⁽²⁰⁵⁾	?

^aOne plus—shown in one study; Two pluses—shown in 2 studies; Three pluses—shown in 3 or more studies.

^bOne plus—study shows deformity is predictive of future morphometric vertebral fracture; Two pluses—studies show deformity is predictive of future morphometric vertebral fracture; risk also shown for future non-vertebral fracture *or* risk shown to be independent of bone density; Three pluses—studies show predictive of future morphometric vertebral fracture *and* non-vertebral fracture, independent of bone mineral density.

than using the height ratios) more than three standard deviations below population gender-specific norms.^(181,183) Ross also validated this definition by showing that *incident vertebral fractures* on follow-up radiographs would by and large be identified as *prevalent* vertebral deformities by his definitions, and that his definition identified these fractures with greater sensitivity than two other morphometric definitions based on reduced height ratios ⁽¹⁸¹⁾.

The quantitative methods of McCloskey et al. ⁽¹⁸⁵⁾, Eastell et al. ⁽¹⁸⁷⁾, and Melton et al. ⁽¹⁾, have been shown to have high test-retest and inter-observer reliability ^(188,189). Several morphometric methods have good *concurrent validity* in that cross-sectional studies have documented a negative correlation between the presence of morphometric deformities and BMD ^(1,6,8,51,190). Finally, several morphometric methods have good *predictive validity* in that a prevalent vertebral deformity meeting those definitions are predictive of incident fractures independent of bone mineral density ^(14,15,17,24,190).

Quantitative morphometric methods have come under criticism, however, first because up to 24% of true vertebral fractures are endplate fractures that do not meet the height loss criteria ⁽¹⁹¹⁾, and second because they do not distinguish between deformities with short vertebral heights due to fracture and those caused by other conditions such as Schuermann's disease, osteoarthritis, and developmental variation ^(192,193). They also are very time-consuming and cumbersome to perform, requiring a technician to carefully mark the six vertebral margins to measure the above stated height ratios on all 13 vertebrae from T4 to L4 ⁽¹⁹⁰⁾.

For these reasons, Genant et al. developed the semi-quantitative method ⁽¹⁹⁴⁾, which re-introduced consideration of qualitative features of vertebral shape to detect prevalent vertebral deformities, but tethered those shapes considered to

represent vertebral deformity to approximate losses of vertebral height. The SQ method has good inter-observer reliability ^(82,188,189,194), concurrent validity ^(190,195,196), and predictive validity ^(23,72,118), but is much less time consuming than the quantitative morphometry and therefore practical for use in clinical practice.

The Genant SQ criteria do state that non-osteoporotic causes of deformity, specifically osteoarthritis and Schuermann's disease, need to be ruled out qualitatively ⁽¹⁹²⁾. There remains controversy, however, as to whether or not vertebrae that have short anterior height without endplate depression that could be adjudicated as wedge deformities under the SQ criteria, represent true vertebral fractures ⁽³²⁾. Short anterior vertebral height without depression of the endplate, especially in the thoracic spine, is commonly associated with disc space narrowing and anterior osteophyte formation indicative of osteoarthritis ⁽¹⁹⁷⁾. Consistent with this, BMD was found to be no different in male participants in the MINOS study with a grade 1 SQ vertebral deformity compared to men with no vertebral deformities ⁽¹⁹⁸⁾, and isolated SQ grade 1 deformities may not be associated with subsequent vertebral fracture ⁽¹¹⁸⁾. Finally, compared to qualitative assessment of vertebral fracture on magnetic resonance imaging (MRI), SQ deformities are more likely to be true fractures by MRI if there is buckling of the anterior cortex ⁽¹⁹⁹⁾.

The *number* of prevalent vertebral deformities is also associated with the risk of subsequent fractures, and hence two or more grade 1 deformities may be a predictor of incident fracture ^(17,23,24,72,118). The *spinal deformity index* (SDI) has recently been described as the sum of all of the SQ grades of vertebra T4 through L4 ⁽²⁰⁰⁾. In an analysis of the placebo groups of the Multiple Outcomes of Raloxifene Evaluation and Fracture Prevention Trials, the SDI has been shown to have a monotonic association with the risk of subsequent

vertebral and non-vertebral fractures (72,200). The SDI score may be more useful for incorporating prevalent vertebral fracture status into assessments of absolute incident fracture risk than simply identifying the worst SQ grade of any one vertebra or simply identifying individuals as having ≥ 1 or no prevalent vertebral deformities.

Identical SDI scores appeared to have a similar association with incident fractures regardless of the combination of number of fractures and the severity of those fractures that comprised that score. For example, an SDI score of three conferred similar risks of incident fractures, whether or not that score comprised three grade 1 deformities, one grade 1 and one grade 2 deformities, or one grade 3 deformity.

More recently, a qualitative technique called the algorithm-based qualitative (ABQ) method has been advocated (201,202). This method postulates that the most susceptible part of the vertebra to fracture is the endplate within the vertebral ring, and identification of central vertebral endplate deformity is central to the identification of prevalent vertebral fracture (202). Consistent with this hypothesis, vertebrae with a decrease in anterior height but not of middle height by morphometric criteria were *not* associated with reduced BMD (46), or with incident fracture in the EPOS study (160). In the OPUS study of postmenopausal women (203), and among elderly men in the Osteoporotic Fractures in Men (MrOS) (204), study wedge deformities defined by the Genant SQ method but without endplate concavity also are not associated with low BMD. Ad hoc analysis of a third study found that the majority of grade 2 SQ wedge deformities judged not to be fractured by the ABQ method on VFA either lacked endplate depression below the vertebral ring or were uncertain by ABQ due to inability to fully visualize the endplate (205). However, the predictive validity of ABQ for incident fractures has not yet been tested, and whether the ABQ method can be accurately employed by non-radiologists in a clinical setting has not been demonstrated as of yet.

When analyzing VFA images, quantitative morphometry (35,38,206,207), the Genant semi-quantitative method (34,40–43), and most recently the ABQ method have been shown to have good intra- and inter-observer reliability and concurrent validity, which approximates that of standard radiography. With the Genant semi-quantitative method, VFA has limited sensitivity for grade 1 deformities compared to standard radiography (36,41). The inter-observer reliability of the ABQ method on VFA images in one recent study appeared to be very good on standard radiographs but slightly less so on VFA images (205).

Accuracy of Vertebral Deformity Detection With VFA Compared to Standard Radiography. Nearly all studies have noted that a larger percentage of vertebrae are not visualized clearly enough on VFA to be evaluated for deformity (8% to –19% of all vertebrae) (30–32,40,43,204,208), compared to standard radiography. Unevaluable vertebrae are particularly common superior to T7 (30,39), but conversely the majority of vertebral fractures associated with osteoporosis occur between T7 and L3 (4,209). A recent study has suggested that vertebral levels that cannot be evaluated on a lateral

decubitus image may be more clearly demonstrated if a second decubitus image is obtained with the patient lying on the opposite side (210).

The sensitivity and specificity of VFA using the Genant semi-quantitative method for the detection of prevalent radiographic vertebral fractures has been reported in five small to moderate sized studies. The numbers of individuals with paired radiographs and VFA images in these studies ranged from 66 to 203 (36,39,41–43). In per-vertebra analyses, the sensitivity for detection of any deformity (grade 1, 2, or 3) ranges from 53% to 83%, and for grade 2 or grade 3 deformity ranges from 57% to 94%. When analyzed per-person, these studies reported sensitivities of VFA for those with one or more grade 1 deformities to be 52% to 96%, and for those with one or more grade 2 deformities 87% to 98%, if those with moderate to severe scoliosis or unevaluable vertebrae inferior to T6 are excluded. The *specificity* of VFA in these five studies for those with a grade 2 or grade 3 deformity was higher, ranging from 83% to 89% if no individuals were excluded, and from 83% to 94% if those with scoliosis or any unevaluable vertebrae inferior to T6 on VFA were excluded. Crude pooling of the four studies that reported per-person analyses (36,41–43), shows VFA having a sensitivity and specificity, respectively, of 96% and 90% for those with one or more grade 2 or grade 3 deformities on standard lateral spine radiographs.

Adjudication of prevalent vertebral fracture by the ABQ method has also recently been shown to have nearly as good inter-observer reliability on VFA images (kappa 0.65) as on standard radiographs (kappa 0.74), and good agreement between VFA and standard radiography for two readers (kappa scores 0.60 and 0.58) (205).

Discussion

The Genant SQ criteria for vertebral fracture detection is the current clinical method of choice because it is the only one that is both readily usable in clinical practice, and for which multiple studies currently exist demonstrating intra-rater and inter-rater reliability, concurrent validity, and predictive validity. Further research is needed comparing the predictive validity and applicability to clinical practice of the ABQ method and the Genant SQ method.

VFA images are quite accurate for detection of grade 2 or grade 3 Genant SQ vertebral fractures, but have only fair accuracy for detection of mild, grade 1 Genant SQ vertebral fractures.

When Should Additional Spine Imaging Be Performed Following a VFA?

ISCD Official Position

- Reasonable indications for follow-up imaging studies include:
 - Two or more mild (grade 1) deformities without any moderate or severe (grade 2 or grade 3) deformities.

- Lesions in vertebrae that cannot be ascribed to benign causes.
- Vertebral deformities in a patient with a known history of a relevant malignancy.
Grade: Fair-C-W-Necessary

Rationale

Lateral spine radiography can clearly be very helpful to assess vertebrae that are unevaluable on VFA, and also may be useful to determine whether or not apparent grade 1 deformities on VFA are truly consistent with fractures. Some may argue to ignore grade 1 deformities, since at least one isolated grade 1 SQ deformity has not been clearly shown to be associated with incident fracture independent of BMD. However, studies of the placebo groups of the MORE and Fracture Prevention Trial do suggest that two or more grade 1 deformities are associated with significant incident fracture risk (72). Since VFA has poor sensitivity and specificity with respect to SQ grade 1 deformity, we believe that follow-up radiography is indicated to confirm or refute findings of two or more apparent grade 1 deformities.

Non-Osteoporotic Causes of Vertebral Deformity. In addition to short anterior height (often associated with disc space narrowing and vertebral osteophytes), other non-osteoporotic deformities include developmentally deep endplates or Cupid's bow deformity. These are characterized by concavity, usually of the inferior endplate, seen in the center or the posterior half of the endplate on the lateral projection and by symmetrical appearances in adjacent vertebrae. In contrast, true osteoporotic endplate fractures tend to be maximally concave near the center of the vertebra in the lateral projection (211). Schmorl's nodes are focal invaginations of a modest portion of the vertebral endplate in the lateral projection, and do not represent true osteoporotic fractures. These are more commonly seen in men than in women, particularly near the thoraco-lumbar junction (212). Lack of segmentation can create the appearance of a wedged vertebra that comprises two adjacent vertebrae that failed to separate during development. This is recognizable by significantly greater posterior height in the two conjoined vertebrae compared to adjacent vertebrae and the lack of a disc space between them. Paget's disease of bone, recognized as a localized sclerosis and/or resorption within part of a vertebra and hemangioma (recognized as a local qualitative alteration of bone density within the body of the vertebra) were each recently shown within the Epidemiology of Osteoporosis Study cohort to be present in 0.54% of elderly women (213).

Malignancy within a vertebra can of course be a cause of structural vertebral weakness and consequent fracture. Benign causes of a radiographic vertebral deformity are more likely if the person has low BMD, and no evidence of destruction, resorption, or expansion of the cortical margins or multiple biconcave deformities (214,215). A benign etiology for a vertebral deformity on lateral radiography is also more likely if the vertebral deformity has been stable over a long period of time, and if no localized areas of bone resorption

(recognized as a qualitative local loss of bone density within the vertebral body) or sclerosis are seen within the body of the vertebra (216,217). While vertebral malignancy and pathologic fracture can occur in the absence of any of these features, only 3% of clinical vertebral fractures are due to malignancy (175), almost all of which are due to metastatic spread from elsewhere with the exception of those due to leukemia or myeloma (215,216). Additional spine imaging is recommended if one or more deformities consistent with fracture are present in a person with a known history of malignancy with any potential for spinal metastases.

Discussion

Follow-up spine imaging is indicated if two or more grade 1 vertebral fractures may be present, because the accuracy of VFA for grade 1 vertebral fractures is only fair, yet two or more grade 1 vertebral fractures confer significant risk of incident fractures independent of BMD. Follow-up imaging for any vertebral deformities consistent with fracture is appropriate if the patient has a history of malignancy with potential for spinal metastases, and for those without such a history if any findings on the VFA are recognized as consistent with spinal malignancy or that cannot comfortably be attributed to benign causes.

What re the Reporting Obligations or Those Interpreting VFA Images?

ISCD Official Position

- VFA reports should comment on the following:
 - Unevaluable vertebrae.
 - Deformed vertebrae, and whether or not the deformities are consistent with vertebral fracture.
 - Unexplained vertebral and extra-vertebral pathology.
Grade: Good-C-W-Necessary

Rationale

In addition to the obvious obligation to report those vertebrae that have typical osteoporotic deformities, a VFA report should also indicate those vertebrae that cannot be evaluated. If one or more vertebrae inferior to T6 are not evaluable, the follow-up radiography may be indicated particularly if there is a relatively high pre-test probability of a prevalent vertebral fracture being present. Those vertebrae that appear deformed due to benign causes (such as Cupid's bow deformity or Schuermann's disease) should be identified as such so that the physician who ordered the test does not mistakenly assume these represent prevalent vertebral fractures.

Significant changes of osteoarthritis of the spine (osteophytes and/or disc space narrowing) should be reported for two reasons. First, bone mineral density of the spine may be elevated by these changes, and may therefore underestimate fracture risk when significant degenerative changes in the spine are present (218). Indicating the presence of degenerative changes on the VFA image may therefore aid interpretation of spine BMD. Second, accurate assessment of

prevalent vertebral fracture on lateral spine images may be more challenging in the presence of degenerative changes (41,54).

If unexplained vertebral or extra-vertebral pathology that may be of clinical significance is noted, this should be mentioned in the report so that the physician who ordered the test can initiate follow-up diagnostic procedures or treatment, if clinically indicated. The most common extra-vertebral pathology that may be noted is abdominal aortic calcification (AAC). Substantial aortic calcification indicates a higher risk of incident myocardial infarction (219–221). Stroke (221,222), and congestive heart failure (223) independent of other clinical cardiovascular disease risk factors. One recent study noted substantial AAC on VFA images in 17% among a group of post-menopausal women at high risk of vertebral fracture (224).

What, if any, medico-legal requirements exist for VFA imaging and reporting is unclear at this time, and in the judgment of the Expert Panel no specific positions that have a medico-legal basis can be stated currently. In general, practitioners are probably responsible for recognizing and reporting pathology (both expected and unexpected) on VFA images that other professionals with similar training that read these images would be capable of recognizing and reporting (225). However, many instances of missed diagnostic findings do not represent instances of substandard care, particularly if the findings are subtle and/or identical to what can often be seen as part of the normal variation within the population (226).

Discussion

All pathology, both vertebral and extra-vertebral, that may influence the ordering physician's assessment of that patient's clinical status, prognosis, and clinical management should be mentioned in the VFA report. Causes of vertebral deformity that are evident on the VFA image should be stated, so that it is clear what, if any, deformities are likely to be truly due to vertebral fracture. Vertebrae that are unevaluable should be identified in the report, so that it is clear what parts of the thoraco-lumbar spine have been adequately assessed by the VFA.

Additional Questions for Future Research

The following important questions require additional research, to further advance the evidence-based application of vertebral fracture assessment:

- What is the prevalence of prevalent vertebral fracture on VFA in subsets of men defined by age and levels of bone mineral density?
- Among children on chronic systemic glucocorticoid medication, how does the prevalence of vertebral fracture change as a function of age, glucocorticoid dose (cumulative and daily), and diagnosis?
- How predictive are deformities consistent with prevalent vertebral fracture on VFA (as opposed to standard

radiographs) for subsequent vertebral and non-vertebral fractures?

- Is a summary score of vertebral deformities such as the Spinal Deformity Index (SDI) more strongly associated with incident vertebral and non-vertebral fractures than the worst SQ fracture grade?
- Is reduced anterior vertebral height without endplate depression predictive of incident fractures?
- Is endplate depression that does not result in at least 20% mid-vertebral height loss predictive of incident fractures?
- What is the impact of documentation of one or more vertebral fractures on physician and patient fracture prevention behavior?

Summary

Vertebral Fracture Assessment has broad applicability for a substantial proportion of the population for whom bone densitometry is indicated, given that documentation of prevalent vertebral fractures substantially influences assessment of incident fracture risk. The ISCD Official Positions described in this document with respect to indications for VFA, detection of vertebral fractures on VFA images, indications for follow-up spine imaging, and VFA reporting obligations are reflect the current state of knowledge regarding these issues. These positions may change in the future as additional research sheds further light on prevalence and incidence of vertebral fracture in different subsets of individuals, on the predictive validity of different definitions of vertebral fracture, and on how VFA can and does influence fracture prevention therapy.

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