Reporting dual energy X-ray absorptiometry scans in adult fracture risk assessment
Dual energy X-ray absorptiometry (DXA) scanning of the central skeleton is the accepted technique for the diagnosis of osteoporosis in terms of bone densitometry. Measurements are usually performed in the context of a comprehensive fracture risk assessment utilising additional information about individual clinical risk factors. The following guidance has been prepared to update the previous recommendations from the National Osteoporosis Society on the interpretation and reporting of fracture risk assessment incorporating DXA scans.

This practical guide describes the reporting of DXA of the proximal femur and lumbar spine in adults within the context of fracture risk assessment. Additional components of a comprehensive fracture risk assessment, such as vertebral fracture assessment (VFA) scanning, and detailed clinical risk factor profiles, are also considered. This guide is based on the expert opinion and clinical experience of the authoring group, and informed by the existing evidence base.
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Key recommendations

1. Bone mineral density (BMD) measurements by dual energy X-ray absorptiometry (DXA) at the lumbar spine and proximal femur remain the ‘gold standard’ for the diagnosis of osteoporosis.

2. BMD measurements should be interpreted in association with other data on fracture risk, including age and prior fracture history, to make individualized clinical decisions and recommendations to the referrer. The World Health Organisation’s (WHO) fracture risk assessment tool (FRAX) has been designed to incorporate a number of key risk factors and provides a 10-year fracture risk.

3. The basis of the recommended reporting system is the WHO study group definitions of osteoporosis, osteopenia and normal, based on BMD T-scores ≤ –2.5, between –2.5 and –1, and ≥ –1 (respectively).

4. The WHO definitions of osteoporosis, osteopenia and normal, apply only to BMD measurements of the spine, proximal femur or distal forearm in post-menopausal women, and should not be applied to other DXA measurement sites or measurements made with technologies other than DXA.

5. Before reporting a DXA study, careful visual scrutiny of the scan images is essential to identify factors that may invalidate the result.

6. When reporting follow-up scans, the images should be carefully reviewed to ensure that the positioning of the patient and placement of the regions of interest are consistent. Other factors that may affect the validity of the measured BMD change should also be considered.

7. The proposed structure of the report is as follows:
   • Biographical information and reason for referral.
   • BMD results, including rate of change and diagnostic categorisation where appropriate.
   • Information about the technical validity of the measurement.
   • Clinical risk factor profile, including fracture history and results of VFA where available.
   • Clinical interpretation which could include ten year fracture risk.
   • Recommendations for management, including advice on treatment, lifestyle modification, further investigation, falls risk and follow-up.
Bone densitometry is well-established in clinical practice. It is generally accepted that DXA is the ‘gold standard’ technique for the measurement of BMD. The ability to measure BMD has had a major impact on our ability to diagnose osteoporosis and assist in decisions about treatment. There are many reviews relating to DXA technology, but at a practical level there is often confusion among different clinicians as to what precisely a DXA result means, how to interpret the result in the light of other clinical information and how to apply this to therapeutic decision-making for an individual patient. The purpose of this guide is to address these issues and to provide some recommendations on structured reporting of fracture risk assessment in adults based around DXA measurements obtained at the lumbar spine and hip. Advice on the use of DXA measurements in children and the use of other techniques, including peripheral BMD measurements and quantitative ultrasound, is included within other publications by the National Osteoporosis Society (available via www.nos.org.uk/professionals).

Dual energy X-ray absorptiometry (DXA)

DXA is the most widely used method for measuring BMD because of its established advantages in clinical use; specifically, exposure to very low doses of ionizing radiation, good precision, short scan times and stable calibration. DXA equipment allows scanning of the spine and hip, which are usually regarded as the most important measurement sites. This is because the predictive ability of BMD for fracture is site-specific, and the spine and hip are common sites of osteoporotic fractures associated with substantial impairment of quality of life, and increased morbidity and mortality. A measurement of hip BMD has been shown to be the most reliable way of evaluating the risk of hip fracture\textsuperscript{1,2}.

Additionally, since the vertebral bodies are rich in metabolically active trabecular bone, the spine is regarded as the optimum site for measuring change in BMD\textsuperscript{3}. The relationship between bone density and fracture is described by a continuous gradient of risk. Figure 1 shows the relationship between hip bone density and risk of osteoporotic fracture when moving from the highest (I) to the lowest (IV) quartile of BMD\textsuperscript{4}.
Figure 1 Comparison of the relationship between femoral neck BMD and the risk of hip fracture with the relationships between blood pressure and the risk of stroke and serum cholesterol and the risk of death from myocardial infarction. In each case the population is divided into quartiles and the relative risk of the higher-risk quartiles is plotted relative to the lowest-risk quartile (figure reproduced with permission).

The fundamental principle behind DXA is the measurement of the transmission through the body of X-rays of two different photon energies. Since the attenuation coefficient depends on atomic number and photon energy, measurement of the transmission factors at two energies enables the ‘areal’ densities (i.e. the mass (g) per unit projected area (cm²)) of two different types of tissue to be inferred. In DXA scanning, the two tissue types are taken to be bone mineral (hydroxyapatite) and soft tissue, respectively. As this is an areal density as opposed to a true volumetric density, it is sometimes designated BMD_a. The radiation dose to the patient from a DXA scan is very low (1 to 10 µSv) and is comparable to the average daily dose from natural background radiation (7µSv).
Vertebral fracture assessment (VFA)

Fan beam DXA scanners also enable the acquisition of a lateral image of the thoracolumbar spine. This technique is increasingly being used within fracture risk assessment services because of the role of vertebral fracture as an important determinant of future fracture risk.\(^8\)-\(^10\).

The ionising radiation dose used in vertebral fracture assessment (VFA) is much less than with standard radiographic imaging of the spine (approximately 1% of a comparable X-ray dose for single-energy imaging). Depending on the type of scanner and the presence of a mobile C-arm, images may be obtained with the patient lying supine or in the lateral decubitus position. Interpretation of images obtained using VFA scanning may be performed using qualitative or quantitative methodology.\(^11\)-\(^15\).

Use of VFA has been evaluated in comparison to conventional spine radiographs. Studies demonstrate good agreement in the identification of moderate to severe vertebral fractures\(^12\),\(^16\)-\(^18\) and the VFA technique has the advantages of lower radiation dose, lower cost and accessibility at the point of fracture risk assessment.\(^11\),\(^15\). The utility of VFA scans may be limited in the presence of scoliosis or degenerative change, and up to 20% of vertebrae may be unsuitable for evaluation, particularly in the upper thoracic spine.\(^19\).
In 1994, a WHO study group recommended a definition of osteoporosis based on BMD measurement of the spine, hip or forearm expressed in standard deviation (SD) units called T-scores\textsuperscript{20,21}.

The WHO report also proposed a state of reduced BMD, intermediate between normal bone density and osteoporosis, described as osteopenia. It is important to note that these definitions were derived from epidemiological studies of Caucasian women in their sixties who had sustained hip fractures to define the prevalence of osteoporosis, and were not intended as treatment thresholds for individual patients.

The T-score is calculated by taking the difference between a patient’s measured BMD and the mean BMD of healthy young adults, matched for gender and ethnicity, and expressing the difference relative to the young adult population SD:

\[ \text{T-score} = \frac{\text{Measured BMD} - \text{Young adult mean BMD}}{\text{Young adult standard deviation}} \]

The WHO definitions of osteoporosis and osteopenia are intended to identify patients with high, intermediate and low absolute risk of fracture, respectively. It is important to recognise that the WHO criteria refer only to BMD measurements of the spine, hip or distal forearm. These definitions cannot automatically be applied to other BMD measurement sites, to other technologies such as quantitative computed tomography (QCT) or quantitative ultrasound (QUS), or to individuals other than post-menopausal Caucasian women (e.g. men, pre-menopausal women or non-Caucasians.) In particular, the use of T-scores is inappropriate in children and young adults, who have yet to reach peak bone mass.

There is a smaller evidence base for establishing diagnostic thresholds in men. The International Society for Clinical Densitometry (ISCD) recommends the use of the Caucasian male normative database and a T-score of –2.5 as a diagnostic threshold\textsuperscript{15}. However, the WHO recommends using the same cut-off value as that used to define osteoporosis in women, namely a BMD 2.5 SD or more below the young adult female mean\textsuperscript{22}. This is a topic that requires further clarification in order to standardise the approach used in different clinical services.

The WHO study group definitions of osteoporosis, osteopenia and normal are intended to identify patients with high, intermediate and low absolute risk of fracture, respectively. The rationale for the WHO definition of osteoporosis is that it captures around 30% of all Caucasian post-menopausal women\textsuperscript{23}. This figure approximates to the lifetime risk of fracture for a 50 year-old woman. Furthermore, there is evidence from several clinical trials that a T-score of –2.5 is the threshold below which treatment produces a reduction in fracture risk\textsuperscript{24,25}. Other studies, however, indicate a reduction in fracture risk with intervention independent of baseline BMD\textsuperscript{26,27}. In making cost-effective treatment recommendations it should be remembered that,
even when the relative fracture risk reduction is independent of baseline BMD, the absolute fracture risk reduction will be greater at lower levels of BMD. 28,29.

It can be argued that the WHO definition of osteopenia captures too high a percentage of women to be clinically useful, and nowadays this term is being used less often, particularly in the context of making therapeutic decisions. In contrast, the WHO definition of osteoporosis has had a major influence on clinical practice, to the extent that the question: ‘Does this patient have osteoporosis?’ is now regarded as a T-score issue. However, although the small proportion of individuals with a T-score below –2.5 are at the highest risk of fracture, the majority of fragility fractures occur in the remaining, larger cohort, illustrating the limited sensitivity of BMD measurements.

Alongside the T-score, another useful way of expressing BMD measurements is in Z-score units. 30 Like the T-score, the Z-score is expressed in units of the population SD. However, instead of comparing the patient’s BMD with the young adult mean, it is compared with the mean BMD expected for the patient’s peers, (e.g. for a healthy normal subject matched for age, gender and ethnic origin):

\[
\text{Z-score} = \frac{\text{Measured BMD} - \text{Age-matched mean BMD}}{\text{Age-matched standard deviation}}
\]

Although not as widely used as T-score, Z-score nevertheless remains a useful concept because it expresses the patient’s risk of sustaining an osteoporotic fracture relative to their peers. It is particularly useful in situations when it is inappropriate to use T-score, such as prior to the acquisition of peak bone mass. It can also be useful to consider the Z-score in elderly individuals where a high proportion are classified as osteoporotic according to T-score criteria, even when BMD is normal for age. T-score and Z-score are compared and contrasted in Figure 2, which shows Caucasian female reference data.

Epidemiological studies of the relationship between BMD and fracture incidence are interpreted using a ‘gradient of risk’ model in which fracture risk increases exponentially with decreasing BMD. 31 The findings are expressed in terms of the relative risk (RR), which is the increase in fracture risk for each 1 SD decrease in BMD. Typically, every reduction of 1 SD in BMD equates to a 1.5 to 2.5 increase in the likelihood of fracture.
Use of bone mineral density measurements in fracture risk assessment

BMD measurement is an important predictor of fracture risk. However, risk within an individual is also influenced by a number of other factors that act at least partly independently of BMD. Examples of independent risk factors include:

- The presence of prior fragility fracture
  - This effect is dose-dependent; that is, it increases with the number of prior fractures and also varies with the site of fracture

- Increasing age

- Use of glucocorticoids (especially current use)
  - This is also dose-dependent and is likely to vary with treatment route and dosing regime

- Current smoking habits

- Excess alcohol consumption

- Parental history of hip fracture

Age is one of the most important risk factors for fracture, as illustrated in Figure 3, which shows the independent effects of age and bone density on fracture risk. The presence of prior vertebral fracture is also an important independent risk factor, associated with as much as a five-fold increase in the risk of further vertebral fracture. It is estimated that fewer than 30% of vertebral fractures are clinically diagnosed and even asymptomatic fractures are associated with an increased risk of further fracture. This explains the rationale for the increasing use of VFA scanning in fracture risk assessment strategies.

Figure 3

The independent effects of age and bone density on fracture risk. Adapted from Kanis et al. (figure reproduced with permission).
The World Health Organisation fracture risk assessment tool (FRAX)

There has been much attention given to the integration of the effect of risk factors in an individual, both in the presence of BMD measurement and without. Several algorithms have been developed to quantify fracture risk using clinical risk factor profiling, most notably the FRAX algorithm produced by the WHO. FRAX uses easily obtainable clinical information that may be entered onto an online proforma to generate the 10-year absolute risk of fracture, either at the hip or for all major osteoporotic fractures (clinical spine, forearm, hip and shoulder). FRAX has also been incorporated into the software of some DXA scanners, allowing the score to be produced as part of the scan output. FRAX has been developed to be used in many different populations. The inclusion of the BMD result from the femoral neck enhances the estimation of the 10-year fracture risk.

FRAX results are weighted for the effect of individual risk factors but do not incorporate dose-dependent effects (e.g. of glucocorticoids or multiple fractures). Fracture risk will therefore be underestimated in individuals with multiple fractures, particularly of the vertebrae, and in those taking high-dose glucocorticoids. Data have now been published recommending how the FRAX score may be manually adjusted to take account of steroid dose. Similarly, FRAX does not allow the use of spine BMD values and will underestimate fracture risk, especially at the spine, in individuals with disproportionately low spine BMD. It should also be noted that FRAX cannot be applied to individuals on osteoporosis treatment. The results should therefore only be presented when it is clinically appropriate and should be interpreted taking account of any relevant limitations.

Reference ranges

If the WHO criterion of a T-score ≤ –2.5 is used to define osteoporosis, then it is apparent that any errors in the mean BMD or population SD of the reference group might lead to significant differences in the apparent incidence of osteoporosis when applied to other populations. Issues over the accuracy of these ranges have caused controversy in the past, especially for femur BMD. The largest dataset available is that derived from the US National Health and Nutritional Examination Surveys (NHANES III). A report by the International Committee for Standards in Bone Measurement (ICSBM) recommended use of the NHANES III reference ranges for hip BMD measurements and this is included in the software of major manufacturers of DXA equipment. The same report also recommended use of the total hip region of interest (ROI) for interpretation of hip BMD, instead of the previously widely used femoral neck site. This recommendation was made because of the larger area and therefore improved precision, and the fact that the total hip region is most readily implemented on all manufacturers’ systems.

The ISCD recommend diagnosis on the basis of the lowest T-score from spine, femoral neck or total hip. This will identify a greater proportion of the population as being osteoporotic than using only two sites (e.g. spine and femoral neck). The WHO definition was designed to identify 30% of post-menopausal women as having osteoporosis but inclusion of more sites will increase this, due to the imperfect agreement between BMD results by site, and potentially lead to over-diagnosis.
A careful visual scrutiny of the scan image is important in the interpretation of DXA studies to ensure that the findings are not affected by anatomical artefacts. For spine scans these include degenerative disease (Figure 5); vertebral fractures (Figure 6); and metal artefacts (Figure 7). Their effect on scan interpretation may be assessed by noting the trend in T-score results at each vertebral level.

It is recommended that only one site at the hip should be utilised (in conjunction with the lumbar spine) in diagnosis and the decision over which region to standardise on should be agreed locally. However, the alternative site may be taken into consideration for patient management where the accuracy of the diagnostic site may be impaired, for example as a result of degenerative changes.

One advantage of presenting bone densitometry results in terms of T- and Z-scores is that they avoid the confusion caused by the raw BMD figures which differ between different manufacturers’ equipment. The ICSBM published equations that allow each manufacturer to express their BMD values in a consistent fashion in standardised units (sBMD: units mg/cm²). However, in practice these are of use only in large clinical trials where data from subjects scanned on different equipment are to be combined. This approach should not be used for comparison of BMD results in individuals scanned on different machines. As far as possible, patients attending for follow-up as part of routine clinical management should be scanned on the same DXA equipment as their previous scan.

**Figure 4**
Venn diagram illustrating the effect of using multiple sites for diagnosis. The shaded area indicates the additional proportion of people who would be diagnosed as osteoporotic if a third site were used.

**Scrutiny of the dual energy X-ray absorptiometry scan image**

**Lumbar Spine**

A careful visual scrutiny of the scan image is important in the interpretation of DXA studies to ensure that the findings are not affected by anatomical artefacts. For spine scans these include degenerative disease (Figure 5); vertebral fractures (Figure 6); and metal artefacts (Figure 7). Their effect on scan interpretation may be assessed by noting the trend in T-score results at each vertebral level.
Figure 5

Spine DXA scan (GE-Lunar DPX) showing changes in BMD in L1 and L2 due to degenerative disc disease (spondylosis) with marginal osteophytes on right. The effect of spondylosis on BMD can be seen from the trends in T-score and Z-score values from L1 to L4 shown in the first four lines of the BMD report.

Figure 6

Spine DXA scans (GE-Lunar Expert-XL) showing the development of a vertebral crush fracture at L1 between serial scans. When calculating change, L1 must be excluded from both the original and the follow-up scan.

Figure 7

Spine DXA scan (Hologic QDR4500) showing the effect on BMD of a gold navel ring superimposed over L4.
If the BMD within a lumbar spine measurement of an individual vertebra is significantly affected by an artefact, the relevant vertebra(e) should be excluded from analysis. As a guide, a T-score difference between adjacent vertebrae of more than one SD is indicative of a result that is likely to be inaccurate. Exclusion of any vertebra(e) will impair the accuracy and precision of the result and a minimum of two vertebrae should always be used for diagnosis. If new vertebral fractures are suspected, either by the scan appearance or a reduction in vertebral height/area, this may be evaluated by the use of further imaging (e.g. VFA (Figure 8)). If two evaluable vertebrae are not present or if a valid hip scan cannot be acquired, a measure of BMD at the distal forearm can be used.

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<tr>
<th>Region</th>
<th>BMD</th>
<th>T score</th>
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<tr>
<td>L1</td>
<td>1.008</td>
<td>-1.0</td>
</tr>
<tr>
<td>L2</td>
<td>1.164</td>
<td>-0.3</td>
</tr>
<tr>
<td>L3</td>
<td>1.216</td>
<td>-0.1</td>
</tr>
<tr>
<td>L4</td>
<td>1.109</td>
<td>-0.8</td>
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**Figure 8** VFA performed on a GE-Lunar Prodigy. The appearance of the spine BMD (left) suggests possible vertebral fracture. VFA (right) indicates fracture of L1, L2, L3 and possibly L4. Note that the T-scores do not differ as much as may be expected due to all four vertebrae being affected.

If VFA is unavailable, the referring clinician should be advised about the need for spinal radiographs to ascertain vertebral fracture status, as this may influence management decisions and act as a baseline for future assessment.

For spine BMD scans it is also important to check that the correct vertebrae have been chosen for analysis. Scan analysis may sometimes be performed by mistake on T12–L3 or L2–L5. Another source of confusion is in patients with abnormal segmentation (e.g. transitional/six lumbar vertebrae). Particularly in elderly subjects, the spine scan may be of little diagnostic value (e.g. if there is extensive degenerative disease). In such patients the hip BMD may provide a more reliable measure of skeletal status and it may be helpful to obtain an additional measurement at the distal forearm.
Proximal femur

Careful scrutiny of the scan image is also important for femur studies. The hip can show a range of anatomical variants or pathological conditions, some of which may make the correct placement of the standard ROI boxes difficult (e.g. a short femoral neck, Paget's disease of the femur or severe osteoarthritis). Incorrect rotation or abduction of the leg is also a source of error. Correctly positioned and correctly analysed hip DXA scans are shown in Figure 8 for Lunar and Hologic densitometers. With the correct degree of internal rotation, the lesser trochanter is just visible. Sometimes optimum hip positioning cannot be obtained, even by the most experienced technicians, due to patient limitations (e.g. osteoarthritis, previous stroke etc). Information on difficulties with patient positioning or image analysis should be passed on to the individual reporting the DXA scans.

Figure 9
Correctly positioned and correctly analyzed femur DXA scans for:
(A) a GE-Lunar densitometer and
(B) a Hologic QDR densitometer.
Note the slightly different regions of analysis utilised by the two scanner manufacturers.

Both spine and femur scans need to be checked to ensure that the bone edge markers are correctly positioned. The densitometer algorithms that calculate these are not infallible and manual correction of bone edge markers and intervertebral markers may need to be performed in some cases. The adjacent soft tissue, used in the calculation of the soft tissue baseline, should also be free of artefact. Abnormally low or high body mass associated with abdominal thickness outside the range of the densitometer (usually 10 to 30cm) may affect the accuracy of the measured BMD and should be noted in the report. Within this range, use of the appropriate scan mode can help reduce inaccuracies. The patient’s date of birth must be entered correctly into the densitometer database, since this will affect the calculation of the Z-score.
Follow-up scans

Inspection of scan images is particularly important when interpreting follow-up studies. A visual comparison should always be made with previous studies. For the spine, a check should be made that the same vertebrae have been used in the analysis and that the projected area of each vertebra remains the same. For the femur scan, it is important that the angles of rotation and abduction of the hip are the same and that the ROI boxes have been placed in a consistent manner.

Ideally, repeat scans should be performed on the same machine, using the same scan mode. Where a previous scan was performed using an older software version, this should be reanalysed using the newer software in order to make a valid comparison with the current scan. If available and recommended in the manufacturer’s instructions for the relevant software release, the compare facility should be used for positioning of previous regions on the current scan. The patient’s weight needs to be checked since major weight change can also affect the scan result due to changes in body fat.

It is important to remember that a change in software since a previous scan, or a new X-ray tube, may substantially alter the precision of the scanner and add additional variation to the measurements that must be allowed for when calculating ‘least significant change’ (see below). Change should be calculated as a change in BMD and not in T-score or SD.

Follow-up DXA scans may be performed to monitor response to osteoporosis treatment or to monitor change in BMD in individuals not taking treatment. The appropriate interval between serial BMD scans is determined from the concept of the ‘least significant change’ in BMD and the anticipated change over time. For any change in BMD to be ‘true’ with 95% confidence, the measured change must exceed 2.8 (or $2\sqrt{2}$) times the precision error (or coefficient of variation) of the measurement.

Although the coefficient of variation for PA lumbar spine and total femur BMD measurements is often quoted as 1%, it is important to realise that this is an idealised figure that applies only to short-term precision measurements (i.e. repeated measurements made over periods of a few hours or days) in healthy young adults with normal BMD and normal weight for height. In practice, the relevant figure for precision is the long-term precision error measured over months or years. Patel et al., reported long-term precision errors of 1.6% for lumbar spine and total femur BMD, thereby producing a figure of 4.5% for the least significant change. The least significant change may be considerably greater, however, for example in patients with very low BMD or in those with high body mass index (BMI) (i.e. BMI > 30 kg/m²), and care is therefore required when interpreting BMD changes in such subjects.

Since it is unlikely that a significant change in BMD will be detectable in less than two years, BMD scans are normally not repeated more frequently than this. However, in situations where clinically expected rates of change exceed the normal, for example in a patient treated with high-dose glucocorticoid therapy, a shorter follow-up interval may be considered. In all cases, a follow-up scan should only be considered where this may influence patient management and is in accordance with the locally agreed service specification and relevant guidelines. It should be noted that change in BMD in response to treatment is not closely associated with fracture risk reduction.
Clinical interpretation

The clinical interpretation of any fracture risk assessment needs to take account of the reason for referral and all the clinical information available. This is usually collected systematically using a questionnaire (for an example, see Appendix 1).

The principle underlying interpretation is to estimate the absolute fracture risk from the available information and to use this to inform clinical decisions about the need for further investigation, treatment and follow-up. The assessment may also indicate the need for more detailed evaluation of falls risk and may contain information influencing the choice of treatment, such as renal function or presence of gastrointestinal disease.

Treatment recommendations should take account of the relative risks and benefits of treatment in the individual patient and, where applicable, should be consistent with local and national guidance.$^{53,55-65}$

A proposed structure for fracture risk assessment reporting

The remainder of this document outlines a scheme for reporting fracture risk assessment, that may be adapted to develop a template to fulfil locally commissioned services. Reporting should be completed in the context of a clear healthcare governance framework. Technical aspects of the report may be completed by the technician who acquires and analyses the scan. However, the clinical interpretation and recommendations should be performed by a medical practitioner with experience in the management of osteoporosis. Within individual service models some aspects of interpretation may be delegated to other appropriately trained and experienced healthcare professionals. The criteria for delegation should be clearly defined and documented in accordance with local commissioning agreements and may refer to locally agreed protocols. The ultimate responsibility for advice given within a report lies with the responsible physician. The algorithm in Figure 10 illustrates the components of the reporting process and indicates which elements may be addressed by non-medical staff and which require medical responsibility.
The blue shaded boxes indicate elements that may be completed by non-medical staff. The orange shading indicates elements that require medical responsibility.

**Figure 10** Flowchart of DXA interpretation and reporting (left) with factors to be considered at each stage (right).
Structure of the report

The report should take no more than a single A4 sheet and it is suggested that a reporting template is developed to allow systematic reporting. It may also be appropriate to enable access to the DXA images, particularly if digital systems (such as Picture Archiving and Communication Systems: (PACS)) are available, but this should not replace the report. An example of a generic template is included in Appendix 2. All reports should contain the following information:

- Details of the scanning service and referrer
- Biographical information and reason for referral
- BMD results including diagnostic categorisation (WHO) and read code where appropriate
- Information about the technical validity of the measurement and, in the case of serial measurements, rate of change
- Clinical risk factors including fracture history, results of VFA and any additional investigations as available
- Clinical interpretation which may include ten year fracture risk calculated using FRAX if this is appropriate
- Recommendations for management including advice on treatment, lifestyle modification, further investigation, falls risk and follow-up
- Details of reporting/authorising physician.

Details of the scanning service and referrer

This section needs to briefly summarise relevant information about the service including contact details and the type of scanner used. It is also important to state that measurements should not be compared between different scanners.

If a patient has been referred from a secondary care referrer it is good practice to copy the report to their primary care physician.

Biographical information and reason for referral

The patient’s date of birth, hospital/NHS number and date of scan should be recorded. It is useful to record the reason for referral and may also be helpful to record gender, height, weight and BMI.

BMD results including diagnostic categorisation (WHO) and Read Code where appropriate

Presentation in tabular format is probably the most concise and clear. The absolute BMD value for the spine and hip (femoral neck or total region) should be given together with the T-score for each region. It is also useful to include the Z-score and this may be reported as the percentage expected for age rather than as a standard deviation score, as the percentage is generally more accessible to the patient. Consideration should be given as to whether the use of WHO categorisation is appropriate or whether there may be a cause other than osteoporosis for low measured BMD such as osteomalacia.
DXA will not differentiate low bone mineral calcium being due to osteoporosis or osteomalacia.

The WHO diagnostic classification is generally based on the value of the lower of the two measurement sites and separate classification for different measurement sites should not be given. It is helpful for coding purposes in the patient’s medical records to include the relevant Read Code. If it is inappropriate to use the WHO T-score classification, (e.g. in a young subject or if the BMD measurements are unreliable), this should be stated and the reason given.

For a follow-up measurement, the rate of change should be reported. This may be reported as the absolute or percentage change at each site with the interval between scans given, or may be reported as an annualised rate of change. Any change in height or weight over the same period of time should be stated.

**Information about the technical validity of the measurement and rate of change in the case of serial measurements**

This section should comprise a brief comment about the technical validity of the measurements. This will highlight artefacts necessitating exclusion of measurements of one or more vertebrae or difficulty with optimal positioning, which may affect the accuracy and precision of the measurement. The direction in which the measurement is likely to be artefactually misleading should be indicated.

For example, the presence of degenerative change or severe aortic calcification is likely to lead to an overestimate of spine BMD, whereas an unusually small skeletal size will result in an underestimate of true BMD at both spine and hip, as DXA measurements are size dependent.

In addition to artefacts visible on the scan image, treatment (current or prior) with strontium ranelate will produce an artificially high BMD and this needs to be taken into account in the interpretation of the DXA scan.

In the case of serial measurements it is important to highlight factors that will artefactually influence the measured rate of change. These factors may include the presence of significant weight change, progression of degenerative changes, a new vertebral fracture or poor repositioning.

**Clinical risk factors including fracture history, results of VFA and any additional investigations as available**

Details of the fracture history should be summarized. Data on the predictive ability of prior fractures predominantly relates to fractures after the age of 40 and, except in unusual circumstances, it is probably not necessary to report fractures in childhood or young adult life. If the mechanism of fracture is known it may be useful to indicate whether it is thought to have involved significant trauma or not.

VFA results may be reported in this section. If a vertebral fracture is suspected from the VFA image, it should be stated whether this has been confirmed with spine radiographs and, if not, whether this is recommended to differentiate a fracture from other pathology. If the VFA has not clearly visualized the whole spine from T4 to L5, this should also be documented together with advice to consider spine
radiographs if the patient is considered to be at high risk of fracture, for example from knowledge of height loss. Radiographs should not be recommended simply on the basis of an inadequate VFA image, as the clinical threshold for performing VFA is much lower than that for performing spine radiographs, which involve a higher radiation dose.

The individual risk factors identified from the patient questionnaire can be summarized in bullet-point format to be concise.

**Clinical interpretation**

This section will attempt to integrate all the information obtained from the BMD measurement, clinical information, reason for referral and any other available investigations, in order to give an estimate of the individual’s absolute fracture risk. In an untreated individual it may be helpful to use a tool such as FRAX to generate a 10-year fracture risk but to comment on the result this provides in the knowledge of any additional information about the individual, such as the presence of vertebral fractures, high-dose glucocorticoids or very low spine BMD.

In the case of serial BMD measurement, the significance of the rate of change should be commented on. The statistical significance will depend on the magnitude of change in the context of an estimate of the precision of the measured change, taking the individual circumstances into account. The clinical significance will depend on the clinical circumstances. For example, bone loss of 2% per year (i.e. 6% over three years) is not unexpected in the early years post-menopause, but bone loss of a similar magnitude in an individual receiving anti-resorptive therapy may indicate a suboptimal response. In general, the magnitude of change will rarely reach clinical significance unless the measurements are at least two years apart.

**Recommendations for management including advice on treatment, lifestyle advice, falls risk assessment, further investigations and follow-up**

The report should state clearly whether treatment is indicated or not. Depending on local agreements, the report may also recommend which treatment to use or refer to locally agreed protocols. Ideally, treatment recommendations should be consistent with available guidance. Note that the BMD thresholds at which treatment is recommended differ depending on the clinical situation. For example, treatment should be considered in cases of glucocorticoid-induced osteoporosis at a T-score threshold of $-1.5^{56,67}$. It is important that local agreement is reached and that the recommendations are consistent with local policy.

The fracture risk assessment may indicate the need for further investigation, which may include referral to a specialist clinic. Indications that may trigger the need for investigation include:

- BMD low for age (i.e. Z-score below $-2$), particularly in pre-menopausal women and men under 75 years of age
- Unexplained bone loss on serial scans
- The presence of previously undiagnosed vertebral fracture
- Clinical suspicion; for example, history of weight loss, risk factors for vitamin D deficiency.
Optimisation of bone health does not only involve appropriate use of osteoporosis therapy. Lifestyle modification should be recommended if adverse factors are identified, even in the presence of a low current fracture risk. Similarly, the assessment may have highlighted a history of falls or suggest a high falls risk, and this should be included in the report.

If the service has provision for follow-up BMD measurement to be carried out, the report should state clearly whether and when this should be performed. In most circumstances the minimum period between measurements should be two years. This would be appropriate timing to assess for treatment response or to identify accelerated bone loss. A repeat assessment should only be recommended if the result will inform clinical management, and in many cases it may only be necessary to perform a further assessment if the individual develops new risk factors.

**Details of reporting/authorising physician**

The name and contact details of the individual performing the report should be stated. In the case of delegated reporting, the supervising physician should also be named.
Appendix 1

Example clinical information questionnaire

METABOLIC BONE CENTRE PATIENT QUESTIONNAIRE

Please complete this form as best you can. It will take approximately 15 minutes. The information will be used to advise you and your doctor of the best way to keep your bones healthy. All answers will be treated in the strictest confidence. If you need any help filling in this form please ask when you attend for your appointment.

About You

Name: .................................................................................................................................

Address: ................................................................................................................................

Telephone no: ..............................................(home) .............................................(mobile)

Occupation (current or before retirement) ...........................................................................

Date of birth: .............................................. Age: ................................................

GP name: ...........................................................................................................................

GP address: ..........................................................................................................................

How tall were you when you were age 25? .....................................

Have you ever broken (fractured) any bones?  YES ☐ NO ☐

If YES, please fill in the table below:

<table>
<thead>
<tr>
<th>Which bone?</th>
<th>Age broken</th>
<th>How did it happen?</th>
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Have you fallen in the last six months?  YES ☐ NO ☐

If YES, how many times have you fallen? .................................................................

If YES, did you fall because you felt dizzy or had a blackout? Please describe what happened............................................................................................................................................................................................
...........................................................................................................................................................................................................................................................................................................
...........................................................................................................................................................................................................................................................................................................

Have you ever had severe back pain lasting more than a few days?  YES ☐ NO ☐

If YES, when and how do you think it started?
...........................................................................................................................................................................................................................................................................................................
...........................................................................................................................................................................................................................................................................................................
...........................................................................................................................................................................................................................................................................................................

Have you had any back/spine X-rays taken in the last twelve months?  YES ☐ NO ☐

If YES, at which hospital? ..................................................................................................................
About your health

Do you have any health problems that have been diagnosed by your GP or at hospital?

YES □ NO □

If YES, please describe...........................................................................................................................................
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Have you ever had any operations? YES □ NO □

If YES, please describe (with dates if possible)........................................................................................................
..............................................................................................................................................................................
..............................................................................................................................................................................
..............................................................................................................................................................................
..............................................................................................................................................................................

Are you taking any medication? YES □ NO □

If YES, please list everything (with doses if possible). Please include details of *tablets, medicines, creams, inhalers and injections*. Please tell us about prescribed treatment and treatment you buy yourself.

<p>| | | | |</p>
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</tbody>
</table>

Have you ever taken steroid tablets (e.g. prednisolone) YES □ NO □

If YES, when did you start taking them (approximately)? ..................................................
What dose are you taking? ..............................................................................................................
What is the highest dose you have taken? ....................................................................................
If you have stopped taking them, when did you stop (approximately)? .........................
Are you allergic to anything?  YES  NO
If yes, please say what you are allergic to and describe your reaction.

Have you taken treatment to make your bones stronger?  YES  NO
(eg Alendronate, Alendronic acid (Fosamax), Etidronate (Didronel PMO), Ibandronate (Bonviva), Risedronate (Actonel), Raloxifene (Evista), Strontium ranelate (Protelos) Teriparatide (Forsteo), Zoledronate (Aclasta):
If YES, which one?......................................................................................................................
If YES, when did you start taking them (approximately)?..........................................................
If you have stopped taking them, when did you stop (approximately)?.................................

About your lifestyle

How much milk do you use each day (e.g. in drinks, on cereal etc)?
Less than ½ pint  ½ to 1 pint  More than 1 pint

How often do you eat cheese &/or yoghurt?
Never  Less than once a week  Once/twice a week  Most days

Do you take cod liver oil?
YES  NO

On average, how often do you spend at least half an hour out of doors?
Never  Less than once a week  Once/twice a week  Most days

Do you take regular exercise, including activity at work?  YES  NO
If YES, what type of exercise (include walking and gardening) and how long do you exercise for e.g. number of miles/hours walked each day?
..............................................................................................................................................

Do you ever drink alcohol?  YES  NO
If YES, how many days a week do you drink? .......................................................................... How many drinks do you have per day? ......................................................................
Do you smoke?

YES NOW □       NOT NOW, but in the past □       NEVER □
If you have stopped, how old were you when you stopped? ........................................

About your family

Do any of your close relatives have osteoporosis (thin bones)?

YES □       NO □
If YES, what is their relationship to you? ..........................................................

Have any of your close relatives broken a hip?

YES □       NO □
If YES, what is their relationship to you? ..........................................................
How old were they when they broke their hip?..................................................

To enable us to analyse your scan we have to know your ethnic background. How
would you describe yourself? (please tick box)

Caucasian (white) □       Asian □       African or Caribbean black □
Oriental □       Other □ (please state)................................................................
..........................................................................................................................

For women – please complete this section

How old were you when your periods started? ..................................................

Are you still having regular periods (eight or more each year)?

YES □       NO □
If NO, how old were you when you had your last period?.........................

Did your periods ever stop for more than three months (except during pregnancy and at
the menopause)?

YES □       NO □
If YES, please say when and why ........................................................................
..........................................................................................................................
Have you ever had contraceptive injections?
  YES now □  NOT NOW, but in the past □  NEVER □
If YES how long did you have them for? …………………………………………………………………………………
………………………..…..

Do you experience menopausal symptoms now?  YES □  NO □

Have you ever taken hormone replacement therapy (HRT)?
  YES now □  NO □  NOT NOW but in the past □
  If you took / are taking HRT, how old were you
  • when you started taking it?…………………………………………
  • when you stopped taking it?  ……………………………...…………..

Have you had a hysterectomy?  YES □  NO □
If YES, how old were you?............................

Have you had either of your ovaries removed?  YES □  NO □
If YES, how old were you?............................
If YES, how many ovaries were removed?  ONE □  TWO □

Had your periods stopped before you had the hysterectomy?  YES □  NO □

Did you experience menopausal symptoms after the hysterectomy (eg flushing, night sweats)?  YES □  NO □
If YES, when?  Straight away □  Months later □  Years later □

Thank you for completing this questionnaire
Appendix 2
Example reporting template

Address of DXA Scanning Service
Referrer name/address

**Patient details:** name, address, date of birth (see page 19: Biographical information and reason for referral)

The above patient attended for a bone mineral density (BMD) assessment by DXA (**equipment make**) on dd/mm/yyyy. The results are as follows:

<table>
<thead>
<tr>
<th>Site</th>
<th>BMD g/cm²</th>
<th>T-score</th>
<th>Z-score (or %agmatched)</th>
<th>Change since previous (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip*</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*either total hip or femoral neck may be used depending on local protocol

**Scan Quality** (see pages 12-17, ‘Scrutiny of the Scan image,’ and page 21: ‘Information about the technical validity’.)
A sentence on reliability

**BMD Interpretation**
Provide appropriate interpretation (see pages 7-9: ‘Definition of osteoporosis using BMD and page 21: BMD results including diagnostic categorization…’)
Comment on change since previous if relevant (pages 17-19: ‘Follow-up scans’, page 21: BMD results including diagnostic categorization….and page 21-22: ‘Information about the technical validity’…)

**Vertebral Fracture Assessment** (page 6, and page 22: ‘Clinical Risk Factors’….)
Comment on VFA if performed

**Fracture History** (page 22: ‘Clinical risk factors including fracture history’..)
Include details of relevant fractures

**Risk Factors for Fracture** (page 22: ‘Clinical risk factors including fracture history’..)
Summarise other risk factors for fracture

**Clinical evaluation** (pages 23: ‘Clinical interpretation’ and pages 23-24 ‘Recommendations for management’)
Provide a fracture risk assessment taking into consideration BMD and relevant risk factors
Indicate further investigation required where appropriate
Advise on further referral where necessary
Provide treatment recommendations including diet and lifestyle advice.
Provide a recommendation for follow-up

Reported by:
Name    Signature    Date
References


17. Chapurlat RD, Duboeuf F, Marion-Audibert HO, Kalpakcioglu B, Mitlak BH, Delmas PD. Effectiveness of instant vertebral assessment to detect prevalent vertebral fracture. Osteoporos Int 2006; 17: 1189-95


38. WHO Fracture Risk Assessment Tool. FRAX. www.shef.ac.uk/FRAX 2011;


42. Looker AC, Wahner HW, Dunn WL, Calvo MS, Harris TB, Heyse SP et al. Updated data on proximal femur bone mineral levels of US adults. Osteoporos Int 1998; 8: 468-89


60. Lewis NR , Scott BB. Guidelines for osteoporosis in inflammatory bowel disease and coeliac disease. 2007


About us

The National Osteoporosis Society is the only UK-wide charity dedicated to improving the diagnosis, prevention and treatment of osteoporosis. The charity works to:

• Influence government and campaign to improve and maintain essential services.
• Provide a range of information resources including leaflets on all aspects of osteoporosis for you and your patients, some of which can be ordered in quantities for you to use in healthcare settings.
• Provide a helpline staffed by nurses with specialist knowledge of osteoporosis and bone health.
• Raise money to fund important research.
• Host a major UK scientific conference on osteoporosis for health professionals

Professional membership

Professional membership of the National Osteoporosis Society can make your job easier if you support people with osteoporosis or fractures, or are involved in research connected with osteoporosis.

Your professional membership will mean you can stay up-to-date with new treatments, care and the latest news on research. It means you’ll have a deeper understanding of the condition.

You can also feel proud to be part of an organisation working hard to help those affected by osteoporosis.

To find out more about becoming a professional member, call our membership department on 01761 473287 or visit us at www.nos.org.uk/professionals

President: HRH The Duchess of Cornwall

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