DXA scanning for osteoporosis

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Definition of osteoporosis and scale of the problem

Osteoporosis is characterised by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in the risk of fracture.[1] It is a major public health issue: the impact of osteoporosis lies in its ability to cause fragility fractures – that is, fractures resulting from mechanical forces that would not ordinarily cause fracture. It is estimated that there are more than 200,000 fractures attributable to osteoporosis each year in the UK, causing severe morbidity to the patient and a cost to the NHS exceeding £940 million. For women, there is a lifetime risk of 33% for a fracture; for men the risk is about half this.[2] The most common fractures are of the spine, hip and wrist. In the absence of fracture, the condition remains undiagnosed. As the relatively well population ages and life expectancy increases, the number of osteoporotic fractures in the next half century is expected to at least double.

Key Points

- **DXA scanning is currently the most appropriate tool for diagnosing osteoporosis**
- **Widespread screening is not currently justified. A case-finding strategy which involves identification of patients by evaluation of risk factors and fragility fracture should be used**
- **Risk of fracture is multifactorial**
- **There are several effective treatments to reduce the risk of fracture, including bisphosphonates, selective oestrogen-receptor modulators, parathyroid hormone and strontium. Bone mineral density can be used to monitor response to treatment in individual patients**
- **The National Institute for Health and Clinical Excellence has published recommendations for secondary prevention of osteoporotic fragility fractures in postmenopausal women and is currently assessing primary prevention in postmenopausal women**

KEY WORDS: bone density, DXA, osteoporosis

Measuring osteoporosis

A number of techniques have been proposed for the diagnosis of osteoporosis and measurement of bone mineral density (BMD), including dual-energy X-ray absorptiometry (DXA), quantitative ultrasound and computed axial tomography.

Dual-energy X-ray absorptiometry

DXA is currently the most widely available and standardised test, providing rapid, convenient and accurate assessments of BMD. Patient data are compared with a reference range, matching for age, sex and ethnicity. Comparison is also made with a 'young normal', a person of the same sex and ethnic origin at age 30 to account for the time of peak bone mass. Results are expressed as Z or T scores, defined as the number of standard deviations (SDs) from the age- and sex-matched control mean values and from the mean values in the 30-year-olds, respectively. The T score is used to define osteoporosis under international guidelines (Table 1).[3]

Individual patient analysis may vary with different technologies so a gold standard for diagnosis should be used.[4] The hip is the preferred site of diagnosis with DXA as adequate reference data are available and there is a low precision error.[2] The view of the Royal College of Physicians (RCP) is that hip fractures cause the greatest financial and personal cost.[2] Femoral assessment is particularly useful in the elderly as it gives the highest predictive value for fracture risk. Spinal assessment is generally not suitable in this group as degenerative disease gives falsely elevated results.[2] The spine is, however, of value in monitoring treatment response. For these reasons, in routine practice, measurement of BMD by DXA in the spine and hip is used.

Standard assessment comprises the total value for L1–L4 in the lumbar spine (Fig 1) (except where a particular problem occurs at any vertebra, in which case it is excluded) and the total hip result (Fig 2). Most standard assessments will give data for individual vertebra and hip regions, which may be of value (particularly in the hip) in some individuals.

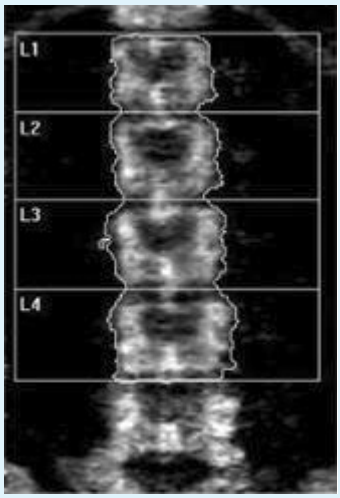
Problems associated with DXA

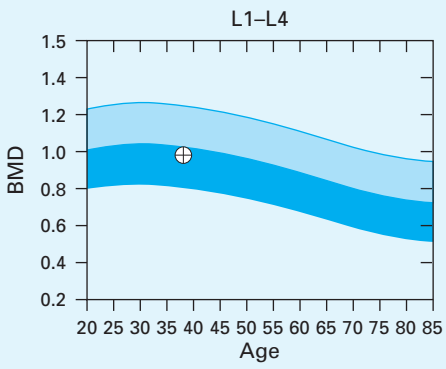
Problems can arise in the assessment at each site. Hip replacement precludes measurement of hip BMD. In the spine, as already mentioned, degenerative disease causes falsely elevated results owing to features such as osteophytes (Fig 3) and compression fractures make the

Table 1. World Health Organization definition of osteoporosis.

T score	
>–1.0	Normal: BMD ≥1 SD below the young adult mean
–1.0 to –2.5	Osteopenia: BMD 1.0–2.5 SD below the young adult mean
<2.5	Osteoporosis: BMD >2.5 SD below the young adult mean
<2.5 with one or more associated fractures	Established/severe osteoporosis

BMD = bone mineral density; SD = standard deviation.





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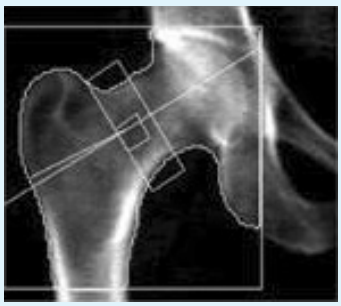
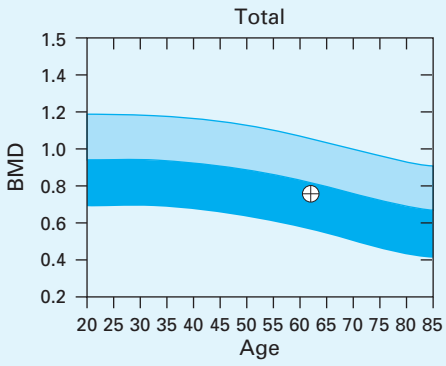
Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T-score	PR	Z-score	AM
L1	10.67	10.47	0.982	0.5	106	0.7	108
L2	12.69	11.78	0.928	–0.9	90	–0.8	92
L3	14.18	14.32	1.010	–0.7	93	–0.5	95
L4	15.56	15.55	0.999	–1.1	90	–0.9	91
Total	**53.10**	**52.12**	**0.982**	**–0.6**	**94**	**–0.4**	**95**

AM = age matched; BMC = bone mineral content; BMD = bone mineral density; PR = peak reference.

Fig 1. DXA scan of the spine. Clockwise from left: scan image of lumbar spine; patient's age and bone mineral density (BMD) plotted with respect to the reference range; BMD figures for individual vertebrae and total spine (L1–L4) with interpretation in terms of T and Z scores.





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Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T-score	PR	Z-score	AM
Neck	5.35	3.22	0.602	–2.2	71	–0.8	87
Troch	11.09	5.77	0.520	–1.8	74	–0.8	86
Inter	16.90	16.10	0.953	–0.9	87	–0.1	98
Total	**33.34**	**25.09**	**0.753**	**–1.6**	**80**	**–0.5**	**93**
Ward's	1.09	0.46	0.420	–3.4	53	–0.8	82

AM = age matched; BMC = bone mineral content; BMD = bone mineral density; PR = peak reference.

Fig 2. DXA scan of the hip. Clockwise from left: scan image of proximal femur; patient's age and bone mineral density (BMD) plotted with respect to the reference range; BMD figures for five regions of interest (ROIs) in the hip (femoral neck, greater trochanter, intertrochanteric, total femur and Ward's triangle) together with interpretation in terms of T and Z scores.

bone appear denser. Other problems that preclude use of the spine include the presence on the scan overlying the spine of recent oral contrast media and metal objects, including zippers, buttons, bra clips and, increasingly in younger patients, navel piercings.

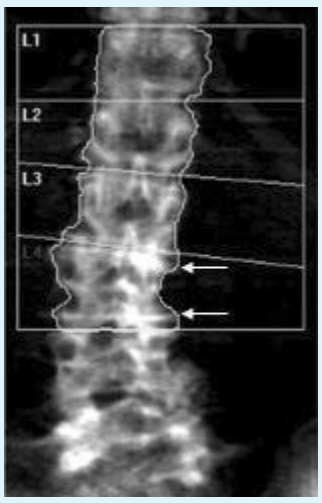
Another problem associated with the use of DXA is that measurements at different sites in an individual or at the same site using different manufacturers' DXA machines can vary widely. The variation due to manufacturing can be overcome by the use of standard values and reference data (standard reference ranges are available). Comparative data can also be derived between machines and manufacturers. In practice, follow-up studies should be performed on the same machine and with the same software if possible. Clinicians should be made aware if different databases have been used.

Does bone mineral density alone predict risk of fracture?

There have been concerns over the value of DXA for prediction of fracture at the site of measurement and, more importantly, at other sites not measured routinely. However, a large number of studies show that BMD predicts overall risk of fracture and is therefore a useful test.[5–7]

Statistics are variable, but a general rule of thumb is that the fracture risk is increased approximately twofold for each SD decrease in BMD.[2] One problem with DXA is how to use the data to decide who to treat, as certainly not all patients with low BMD will experience fractures while some with BMD above the osteoporotic range will do so. Unlike at diagnosis, current RCP guidelines accept the use of alternative techniques such as quantitative ultrasound for assessment of risk.[2]

Fig 3. Part of computer printout from DXA scan of the spine. The image shows degenerative disease at L4 (this appears whiter on the scan), indicating denser bone (arrows). L4 is excluded from the calculation of overall bone mineral density (BMD).



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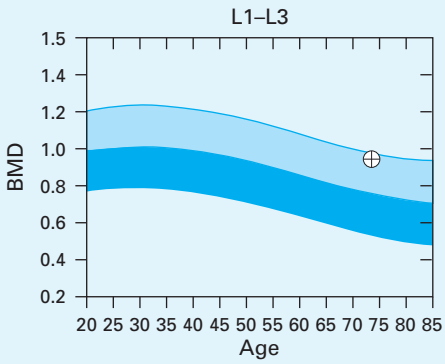

Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T-score	PR	Z-score	AM
L1	12.97	12.26	0.945	0.2	102	2.3	136
L2	12.00	9.67	0.806	–2.0	78	0.3	104
L3	12.82	14.04	1.095	0.1	101	2.5	134
Total	**37.79**	**35.96**	**0.952**	**–0.6**	**93**	**1.7**	**124**

AM = age matched; BMC = bone mineral content; BMD = bone mineral density; PR = peak reference.

Indeed, other predictors of fracture independent of BMD should be sought and assessed in each patient, including:

- advancing age
- previous fracture
- maternal history of hip fracture
- steroid use
- risk factors for falling, and
- markers of bone turnover.[2,8]

Fracture risk is thus multifactorial and full assessment should be made when considering any treatment. An algorithm is currently being developed under the auspices of the World Health Organization that will quantify the absolute risk of osteoporotic fracture on the basis of risk factors. This will be a valuable future tool.

Indications for assessment in the UK

At present there is no universal policy for screening patients for osteoporosis. As BMD itself is an important diagnostic and prognostic tool, and as other factors influence prognosis, it may become possible to develop screening strategies. At present, the RCP recommends a case-finding strategy which involves identification of patients because of a fragility fracture or by the presence of strong risk factors. The RCP has listed a series of indications where BMD assessment should be performed because the result will influence management (Table 2).[2]

Clearly, not all high-risk patients will be identified and some apparently low-risk patients may have a low BMD and suffer a fragility fracture in the future. Despite this, at present the case-finding approach, although believed to be conservative, is economically justified. As the RCP points out, further research is needed into optimisation of this approach.[2]

Diagnostic assessment

When osteoporosis is diagnosed there should be further assessment, exclusion of disease that may mimic osteoporosis and elucidation of any unidentified secondary cause. Routine investigation

Table 2. Royal College of Physicians recommended indications for bone marrow density measurements where assessment would influence management.

- Radiographic evidence of osteopenia and/or vertebral deformity
- Loss of height, thoracic kyphosis (after radiographic confirmation of vertebral deformity)
- Previous fragility fracture
- Prolonged corticosteroid therapy (prednisolone >7.5 mg for $6 months)
- Premature menopause (<45 years)
- Prolonged secondary amenorrhoea (>1 year)
- Primary hypogonadism
- Chronic disorders associated with osteoporosis (eg malabsorption, anorexia nervosa, chronic renal failure, hyperthyroidism, primary hyperparathyroidism)
- Maternal history of hip fracture
- Low body mass index (<19 kg/m^2)

would include full blood count, erythrocyte sedimentation rate, bone and liver function tests, creatinine, thyroid function and, if indicated, serum paraproteins, sex hormones in men, follicle-stimulating hormone in women if menopausal status is unclear, and on occasion lateral spine X-rays and radionuclide bone scan.

The RCP has developed a flow chart for assessment, investigation and treatment in men and women over 45 years who have, or are at risk of, osteoporosis (Fig 4).[9]

Treatment

There are several effective treatments to reduce risk of fracture, including:[10-13]

- bisphosphonates
- selective oestrogen-receptor modulators
- recombinant parathyroid hormone
- strontium.

Treatment in individual patients can be monitored using BMD, with the spine the preferred site. Change is slow and low grade and, given the reproducibility error inherent to the technology, scanning at intervals of less than one year is not justified.

When to treat

Although a T score below 2.5 is well established as a definition for osteoporosis, the level at which a patient should be treated is less clear. It is relatively easy to justify treatment in a 70-year-old female with a low T score and a fragility fracture. More controversial is treatment in the osteopenic patient, especially in the absence of significant risk factors and fractures. Anecdotally, these patients have been treated *ad hoc* in various units, and it has been strongly argued that treatment for osteoporosis is about prevention of the first fracture. It is undoubtedly expensive to treat this group, which includes many women in their 50s who may require long-term treatment. The conclusions are awaited from current considerations by the National Institute for Health and Clinical Excellence (NICE) of the value and cost-effectiveness of primary treatment of osteoporosis (ie in postmenopausal women with low bone density without fracture).

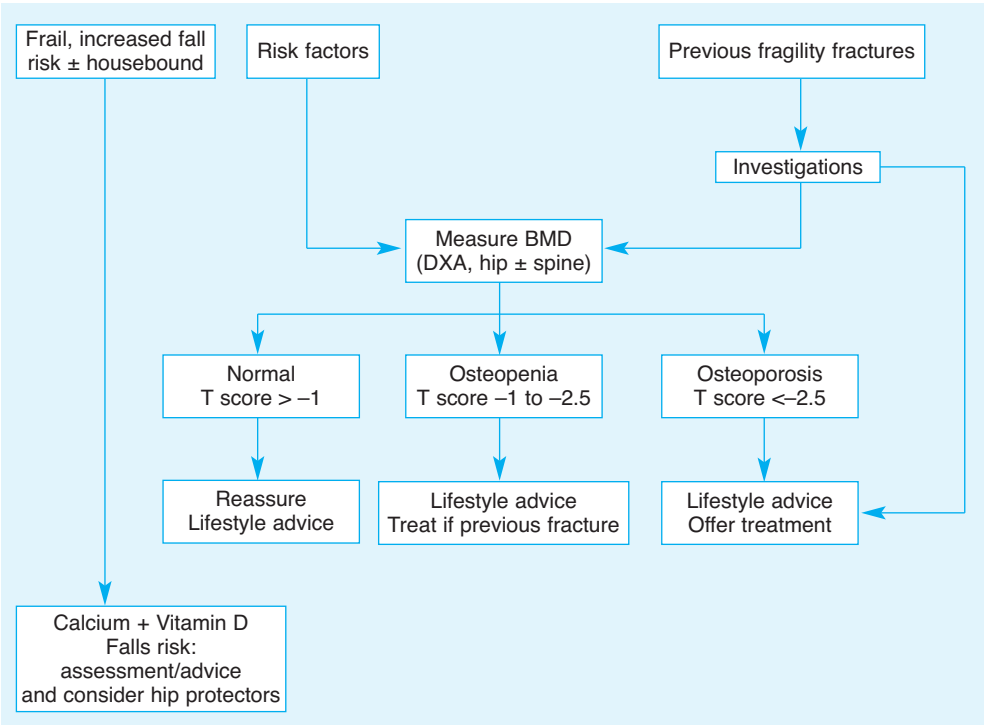

Fig 4. Royal College of Physicians' algorithm for medical management of men and women aged over 45 years who have, or are at risk of, osteoporosis. BMD = bone mineral density.[9]

Secondary prevention

NICE has published guidance on treatment for secondary prevention of osteoporotic fragility fractures in postmenopausal females who have suffered a previous fragility fracture.[14] Separate guidelines will be needed for men and young women. Patients treated with steroids will also need to be considered separately as the fracture threshold is lower and patients will therefore fracture at a higher bone density. Recommended treatment is as follows:

Bisphosphonates

Bisphosphonates (alendronate, etidronate, risedronate) are recommended by NICE in postmenopausal women:

- aged 75 years or over without the need for a DXA scan
- aged 65–74 years if osteoporosis is confirmed with a DXA scan
- below 65-years-old if their BMD is very low (T score ≤–3 SD) or they have a confirmed diagnosis of osteoporosis and the presence of one or more of the following risk factors:
  - very underweight (ie body mass index <19 kg/m^2)
  - their mother had a hip fracture below 75 years
  - an early menopause that was untreated
  - a medical condition that increases the risk of osteoporosis (eg rheumatoid arthritis, chronic irritable bowel disease, hyperthyroidism, coeliac disease) or that prevents them from moving.

Raloxifene

NICE recommends that raloxifene should be given in any of the following situations:

- women currently taking other medicines that may be affected by bisphosphonates or who have another medical condition that means bisphosphonates cannot be used
- those unable to physically manage the way a bisphosphonate has to be taken (eg taking it with a certain amount of water, having to avoid eating for certain periods before or after taking it, and having to remain upright for certain periods after taking it)
- women who have already been treated unsuccessfully for a year with bisphosphonates (eg another fracture has occurred and bone density has decreased to a level lower than before treatment)
- women unable to take bisphosphonate because of the side effects (including inflammation or ulceration of the oesophagus and diarrhoea).

Teriparatide

Teriparatide should be used in women aged 65 years or older if:

- bisphosphonates have not worked (ie after 1 year of treatment with a bisphosphonate, another fracture has occurred and bone density has decreased to a level lower than before treatment) or cannot be taken because of side effects
- they have a very high risk of fracture, as indicated by:
  - T score of –4 SD or less, or
  - T score of –3 SD or less, more than two fractures and at least one of the additional risk factors listed above for bisphosphonates, except in the presence of a medical condition independently associated with bone loss.

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