The prevalence of osteoporosis is about 40%–50% in postmenopausal women and 20% in older men. The limited availability of dual-energy X-ray absorptiometry (DXA) scanners across the country calls for the presence of alternate risk assessment tools to identify those at high risk for osteoporosis. Some of the screening tools available for osteoporosis include Simple Calculated Osteoporosis Risk Estimation and Osteoporosis Risk Assessment Tool for Asians (OSTA), and Fracture Risk Assessment Tool to assess fracture risk. Clinical parameters that may serve as surrogates include dentition and anthropometric indices. Although screening tools do not supplant the assessment of bone mineral density by DXA, they help identify individuals at high risk for osteoporosis who may be selectively referred for confirming the same.

**Keywords:** India, older men, osteoporosis, postmenopausal women, screening tools
Index of Risk. Male Osteoporosis Risk Estimation Score (MORES) is a screening tool for osteoporosis developed to identify men at risk of osteoporosis. All these tools perform similarly and are moderately accurate in predicting osteoporosis. Fracture Risk Assessment Tools (FRAX) such as FRAX developed at the University of Sheffield, and others, including the Garvan fracture risk calculator and the Qfracture scores, are available for estimating fracture risk.

**Development and Validation of Osteoporosis Screening Tools**

SCORE was developed in a cohort of 1102 postmenopausal women and used the parameters of race, the presence of rheumatoid arthritis (RA), history of fractures, age, weight, and the use of estrogen therapy. ABONE was used in 1610 postmenopausal women and used age, weight, and estrogen therapy. ORAI was more categorical and used age, weight, and estrogen therapy parameters and was first validated in the Canadian multicenter osteoporosis study with 926 women aged more than 45 years. OSTa was developed in 860 postmenopausal Asian women in eight countries (China, Taiwan, Hong Kong, Korea, Malaysia, Singapore, Thailand, and the Philippines). OSTA was calculated as one-fifth of the difference between weight in kilogram and age in years.

MORES was developed and validated in 2995 men, ≥50 years old and representative of the general US population, enrolled in the National Health and Nutrition Examination Survey III. Using a weighted scale that includes age, weight, and history of COPD, the MORES identifies men at higher risk of osteoporosis (cutoff ≥6) who should undergo a diagnostic DXA scan.

The parameters utilized in these tools and the cutoffs used to identify postmenopausal women at risk for osteoporosis are shown in Tables 1-4.

In a recent study conducted at the authors’ center, 2108 ambulatory South Indian rural postmenopausal women were assessed with SCORE, ABONE, ORAI, and OSTA. BMD was estimated by DXA scan at the FN, and sensitivity and specificity were calculated for all tools for predicting FN osteoporosis. Osteoporosis at the femoral neck was seen in 27%. The sensitivities of SCORE, ABONE, OSTA, and ORAI ranged from 81% to 91%, with specificities in the range of 35%–52%. Overall, SCORE performed well with an area under the curve (AUC) of 0.806 in predicting femoral neck osteoporosis. Thus, it was inferred that this tool could be used in resource-limited countries to screen the population at risk and enable treating physicians to make appropriate management decisions. In another study undertaken at the authors’ center on 512 men aged 65 years and above, it was found that MORES performed well in predicting osteoporosis at the femoral neck and lumbar spine, with an AUC of 0.760 and 0.885, respectively. OSTA similarly performed well in predicting osteoporosis at the femoral neck and lumbar spine with AUCs of 0.778 and 0.716, respectively. In a similar study done in Northern India on 257 community-dwelling men, OSTA demonstrated an AUC of 0.702 in predicting osteoporosis, and at a cutoff of ≤2, the sensitivity and specificity were 95.7% and 33.6%.

**Other Clinical Surrogates in Predicting Osteoporosis**

**Dentition**

Osteoporosis is a systemic skeletal disease and thus may result in weakening the jawbones. A decrease in bone density of the jaw may result in tooth loss due to poor anchoring of the teeth. Therefore, dentition may serve as a clinical surrogate in detecting osteoporosis. In a study on 150 ambulatory postmenopausal women aged more than 50 years, in which the prevalence of osteoporosis was 39%, it was found that among patients with loss of three or more teeth, the odds of having osteoporosis was 4.2 (95% confidence interval: 2.4–7.3).

**Anthropometry**

Several studies have shown the correlation between anthropometric measures such as weight, waist circumference, hip circumference, and BMD. While

| Screening tools | Cut off point | Risk factors | Score | Conditions |
|----------------|--------------|--------------|-------|------------|
| SCORE          | ≥6           | Race         | +5    | Woman is not black |
|                |              | RA           | +4    | Woman has RA |
|                |              | History of fractures | +4 | For each type (wrist, rib, hip) of nontraumatic fracture after age 45 (maximum=12) |
|                |              | Age (years)  | +3    | Times first digit of age in years |
|                |              | Estrogen therapy | +1   | Woman has never received estrogen therapy |
|                |              | Weight       | −1    | Times weight in pounds divided by 10 and truncated to nearest integer |

SCORE=Race + RA + fracture history + estrogen + (3×age/10) – (weight/10). SCORE: Simple calculated osteoporosis risk estimation. RA: Rheumatoid arthritis.
**Table 2: Age, Bulk, One or Never Estrogen**

| Screening tools | Cutoff point | Risk factors | Score | Conditions |
|-----------------|-------------|-------------|-------|------------|
| ABONE           | ≥9          | Age (years) | 15    | ≥75, 65-74, 55-64, 45-54, <60, 60-69, ≥70 | Weight (kg) | 9 |
|                 |             | Weight (kg) | 9     | 60-69, ≥70 | Estrogen therapy | 3 |
|                 |             | Estrogen therapy | 3     | never received estrogen therapy | |

**ABONE: Age Bulk One or Never Estrogen**

**Table 3: Osteoporosis Risk Assessment Instrument**

| Screening tools | Cutoff point | Risk factors | Score | Conditions |
|-----------------|-------------|-------------|-------|------------|
| ORAI            | ≥9          | Age (years) | 15    | ≥75, 65-74, 55-64, 45-54, <60, 60-69, ≥70 | Weight (kg) | 9 |
|                 |             | Weight (kg) | 9     | 60-69, ≥70 | Estrogen therapy | 3 |
|                 |             | Estrogen therapy | 3     | never received estrogen therapy | |

**ORAI: Osteoporosis Risk Assessment Instrument**

**Table 4: Osteoporosis Screening Tools for Asians**

| Screening tools | Cutoff point | Risk factors | Score | Conditions |
|-----------------|-------------|-------------|-------|------------|
| OSTA            | ≤−1         | Age (years) | 0.2×(body weight [kg] − age [years]) | 15 |

**OSTA: Osteoporosis Self-Assessment Tool for Asians**

**Role of Quantitative Ultrasound**

DXA is indeed extremely precise in the measurement of BMD. However, some of the disadvantages of DXA are that it is expensive, not widely available, and requires the presence of licensed radiographic technicians to perform the scan. The use of calcaneal ultrasound may overcome these drawbacks. These small and portable machines measure the attenuation and speed of sound passing through the heel bone. One of the advantages of the quantitative ultrasound (QUS) is that it does not use ionizing radiation to assess BMD. This may be used in office-based settings and performed with ease by a nurse or a medical assistant. Although critics have questioned the accuracy of the calcaneal ultrasound, the report derived from the ultrasound may be related to the information gleaned from history and clinical examination to gauge the fracture risk in postmenopausal women. In the study mentioned above, on screening tools in 2108 postmenopausal women, QUS was performed in 850 subjects. At a T-score cutoff of ≤−2.5, the sensitivity and specificity of QUS in predicting femoral neck osteoporosis were 82% and 50%, respectively. This further validates the fact that QUS may be an inexpensive and promising screening tool for osteoporosis in primary care.

**Screening Tools for Fracture**

FRAX® is an online tool developed at the University of Sheffield as a screening tool to predict the risk of fractures. FRAX® was developed by analyzing different potential risk factors from 60,000 men and women from 12 prospective cohorts recruited from the general population with a total follow-up of 250,000 person-years. The individual risk factors chosen to compute fracture risk include age, BMD, body mass index (BMI), prior fragility fracture, use of oral glucocorticoids, parental history of hip fracture, current smoking, alcohol intake, and RA. The usage of FRAX® in initiating treatment for osteoporosis varies from country to country. In the US, FRAX is only done in women who have their BMD in the osteopenic range (T score between 1 and 2.5 standard deviation [SD]) and are offered treatment in those with a 10-year probability of major osteoporotic fractures equal to or exceeding 20%, or when the 10-year probability of hip fracture exceeds 3%. As the FRAX tool was validated mostly in cohorts from a Caucasian ethnicity, its use in other countries may require revised cutoffs for therapeutic decision making and follow-up for the occurrence of incident fractures. In another study performed at the authors’ center on 301 postmenopausal women, it was found that FRAX with or without the...
incorporation of BMD predicted fragility vertebral fractures at a cut-off of ≥9% for major osteoporotic fracture and ≥2.5% for hip fracture with sensitivities of 77%–88% and specificities of 55%–72%. Other online fracture risk prediction tools include the Garvan fracture risk calculator, which also has a history of falls in calculating fracture risk, and the Qfracture tool, which incorporates, in addition to falls, various chronic systemic diseases as well. However, these tools have not been validated in many countries, including India. The presence of type 2 diabetes mellitus in individuals poses a unique challenge in BMD assessment in that it is noted to be paradoxically high, although the bone quality is compromised. In a study by Leslie et al., the four methods used to improve the performance of FRAX in subjects with diabetes mellitus include (a) substitution of RA input to FRAX with diabetes mellitus (b) making a trabecular bone score adjustment to FRAX (c) reducing the femoral neck T-score input to FRAX by 0.5 SD and (d) increasing the age input to FRAX by 10 years. Among these changes, replacing diabetes for RA and increasing the age by 10 years may be a pragmatic approach to improve fracture risk prediction in participants with diabetes, without the need for BMD assessment.

PLACE OF SCREENING TOOLS FOR OSTEOPOROSIS IN INDIA

The last four decades have witnessed significant progress in the field of bone densitometry. Besides conventional BMD assessment, currently available DXA scanners are equipped with additional software that can report the integrity of the trabecular microarchitecture and macroscopic hip geometry as well. Vertebral fracture assessment may also be performed simultaneously with an assessment of BMD. However, despite the many advances made in this field, the fact remains that India is home to about 140 million postmenopausal women, with more than half of them residing in rural India. The availability of merely 700–800 DXA scanners across the country is grossly inadequate to cater to the large numbers of women who are truly at risk for osteoporosis. Moreover, the prohibitive costs involved may not appeal to the vast majority.

This forms the premise for utilizing various screening tools to identify individuals at risk for osteoporosis and fracture. It must be reinstated that these tools are readily available, inexpensive, easy to perform and may be used in the community and primary care settings. They do not require technical expertise and may be performed by nurses and physician assistants. The validation of various tools in Indian postmenopausal women and older men proves their utility in resource-poor areas. Although these tools do not replace the need for a DXA scan, those identified to be at high risk may be selectively screened by DXA to confirm the diagnosis of osteoporosis and initiate specific treatment. It is imperative to perform a thorough clinical examination and identify other surrogates of bone loss, such as loss of teeth and a low BMI. FRAX may be used even without BMD with altered cutoffs to predict fracture risk.

When writing this narrative review, our country has been ravaged by the COVID-19 pandemic. With the curbs and constraints imposed to curtail the spread of infection, population mobility is largely restricted. Even in tertiary care centers, screening for osteoporosis by DXA has been hit hard by the onslaught of the pandemic. In the given circumstances, health workers may utilize these screening tools to sift out individuals at high risk for osteoporosis and selectively refer them for formal densitometry.

ENDORSEMENT OF OSTEOPOROSIS AND FRACTURE SCREENING TOOLS BY CLINICAL PRACTICE GUIDELINES

The following statements are from the monogram on Clinical Practice Guidelines on Management of Postmenopausal Osteoporosis by the Indian Menopause Society. The book is available from the web portal of the Indian Menopause Society (indianmenopausesociety.org.)

Osteoporotic fracture risk screening of large-scale whole population groups is not likely to be cost-effective, so more selective approaches, i.e., targeted screening for disease detection, are advocated. Early diagnosis in the asymptomatic period is essential to initiate timely interventions in osteoporosis management and thus
prevent associated morbidity and mortality due to osteoporotic fractures. In asymptomatic healthy women above 40 years, opportunistic screening is suggested for osteoporosis (Refer flowchart in Figure 2).[9] Women falling into the risk group of low bone mass or osteoporosis are further evaluated for fracture risk and are individualized with regards to the treatment plan. Risk assessment factors for fractures are derived by history and clinical examination as well as by relevant investigations.

Risk assessment tools such as the Osteoporosis Self-Assessment Tool (OSTA) for Asians and SCORE Score are simple and cost-effective to screen women at risk for osteoporosis. The WHO FRAX is country-specific, and until more Indian data are available on the prevalence of osteoporotic fractures and mortality rates, it may not serve the true purpose in the Indian context. Screening tools pick up those who need a DXA scan. In case of nonavailability of DXA, clinical risk factors and radiography of the lateral thoracolumbar region would help downstage the burden of osteoporosis and provide a lead for those who need long-term treatment to prevent fractures. Numerous studies have documented inadequate osteoporosis preventive care for patients even after they sustain a fragility fracture. For this reason, they can serve as “sentinel” fractures that allow identification of high-risk patients who could benefit from osteoporosis treatment to prevent further vertebral and hip fractures.

The Indian Society for Bone and Mineral Research states that tools like Osteoporosis Self-Assessment Tool for Asians (OSTA) and MORES have been validated for use in the Indian population. These tools are rapid, easy to perform, inexpensive, and possible to use in the rural Indian setting but the impact of initiating therapy based on thresholds derived using these tools is not well studied.[31]

**Conclusion**

Screening tools are not diagnostic tools, and therefore will never replace BMD assessment by DXA. Notwithstanding, in low- and middle-income countries, where the availability of DXA scanners is limited and unaffordable for many, they may have broader applicability in identifying high-risk individuals.

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There are no conflicts of interest.
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