Trabecular Bone Score (TBS)

From fracture prediction to clinical use

Teheran May 2016

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Osteoporosis…

- Systemic skeletal disease characterised by low bone mass and a micro-architectural deterioration of bone tissue

BMD: the Gold standard

BMD Thresholds are defined by the WHO as follows:

- **Normal**: T-score > -1.0 SD
- **Osteopenic**: T-score ≥ -1.0 SD < -2.5 SD
- **Osteoporotic**: T-score ≤ -2.5 SD

**BUT**: > 50% of osteoporotic fractures occurs in the Normal / Osteopenic Zone

Bone Mineral Density alone?

Bone Quality

Krieg et al ABMR 2007
Osteoporosis is a systemic skeletal disorder characterized by compromised bone strength predisposing a person to an increased risk of fracture.
Contributors to Bone Strength and fracture Risk

Factors of Bone Quality

- Bone Density
- Bone Architecture
- Bone Turnover
- Bone Mineral

Macro-architecture
Micro-architecture
What is TBS?

• TBS is a DXA software program that estimates bone texture information from a regular PA spine DXA scan
  • Is a derived unitless index, not a direct physical measure

• TBS is associated with bone microarchitecture and fracture risk

• TBS provides fracture risk information that is additive to BMD and clinical risk factors

Silva et al. J Bone Miner Res. 2014 29:518–530
Principle of TBS

Example of Different Bone Texture Despite Same L1-L4 BMD

Two patients with Same L1-L4 BMD

Normal trabecular Bone architecture

Homogeneous: High TBS

TBS L1-L4: 1.457

Degraded trabecular bone architecture

Heterogeneous: Low TBS

TBS L1-L4: 1.132

Adapted from Silva et al. J Bone Miner Res. 2014, 29:518–530
TBS results are obtained by post-acquisition processing of the DXA scan

A higher TBS correlates with better bone microstructure

A lower TBS with worse bone microstructure
Primary Osteoporosis & other: 43%
Secondary Osteoporosis: 27%
Treatment: 13%
Guidelines: 10%
Reference Curve: 7%
TBS Endorsement by International Scientific Societies

... TBS is officially recognised worldwide as an Independent fracture risk prediction tool

ISCD  ESCEO  TBS in international guidelines
FRAX  DVO
International Recommendations: ISCD & ESCEO

- Similar outcomes:
  - TBS is associated with fracture, in women and men
  - TBS predicts fracture independently from BMD, CRF and FRAX®
  - TBS predicts fracture in secondary osteoporosis context – type 2 diabetes (ISCD), hyperpara & Glucocorticoid induced OP (ESCEO)
  - TBS should not be used alone to determine treatment recommendations in clinical practice.
  - No guidelines on TBS and treatment monitoring and selection yet

- Major Conclusion: «TBS has «a role in fracture risk assessment with both aBMD and FRAX» and enables to «enhance risk stratification with aBMD»

- TBS iNsight is now also in local guidelines: German DVO & Swiss ASCO
- 33,352 women, Manitoba
- 40-100 yrs, mean 63 yrs
- Mean FU 4.7 yrs
- FRAX clinical risk factors

Adapted from Hans et al., JBMR 2011; Leslie et al., OI 2014
BMD and TBS complementary

- Fracture risk assessed by:

**BMD alone:**

<table>
<thead>
<tr>
<th>BMD Alone</th>
<th>Based on minimum hip or spine BMD T-score</th>
<th>Color Code</th>
<th>Sub-category of risk of Major osteoporotic fracture per 1'000 women per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>≤ 4</td>
<td></td>
</tr>
<tr>
<td>Osteopenia</td>
<td>Osteopenia</td>
<td>[4 - 5]</td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>Osteoporosis</td>
<td>[5 - 7]</td>
<td></td>
</tr>
</tbody>
</table>

**BMD + TBS**

<table>
<thead>
<tr>
<th>Based on Spine TBS</th>
<th>≥ 1.300</th>
<th>1.200 &lt; &gt; 1.300</th>
<th>≤ 1.200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Osteopenia</td>
<td>Osteoporosis</td>
</tr>
<tr>
<td>Osteopenia</td>
<td>Osteopenia</td>
<td>Osteoporosis</td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>Osteoporosis</td>
<td>Osteoporosis</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Table 3 in Hans et al. J Bone Miner Res. 2011 Nov;26(11):2762-9
TBS helps identify new patients at risk of fracture

100% of all fractures
Normal, Osteopenic and Osteoporotic patients by BMD

50% occur in Normal and Osteopenic patients* - not classified at risk based on BMD score

50% occur in Osteoporotic patients - classified at risk by BMD score, most under treatment

(*) More patients in this group

21%
Normal Zone
Aftered TBS
21% reclassified with fracture risk
(Risk has been underestimated by only using BMD)

29%
Osteopenic Zone
Aftered TBS
29% reclassified with fracture risk
(Risk has been underestimated by only using BMD)

5%
Osteoporotic Zone
normal TBS
5% reclassified with fracture risk
(Patients at risk already identified by BMD)

Adapted from Hans et al. JBMR 2011
Can TBS be usefully added to FRAX?

TBS yields risk which is

- independent of BMD
- independent of CRFs
- amenable to intervention
- clinically meaningful

- Sufficient level of evidence (many studies)
- Validation cohort
## Fracture risk and TBS adjusted for CRFs and/or BMD

<table>
<thead>
<tr>
<th>TBS adjusted for</th>
<th>OWH fracture</th>
<th>Hip fracture</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR / 1 SD</td>
<td>HR / 1 SD</td>
<td>HR / 1 SD</td>
</tr>
<tr>
<td></td>
<td>(95% CI)</td>
<td>(95% CI)</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>Time and age</td>
<td>1.35 (1.29-1.42)</td>
<td>1.48 (1.33-1.66)</td>
<td>1.32 (1.26-1.39)</td>
</tr>
<tr>
<td>CRFs*</td>
<td>1.27 (1.20-1.33)</td>
<td>1.40 (1.25-1.57)</td>
<td>1.23 (1.17-1.29)</td>
</tr>
<tr>
<td>BMD</td>
<td>1.25 (1.18-1.31)</td>
<td>1.26 (1.12-1.42)</td>
<td>1.29 (1.23-1.35)</td>
</tr>
<tr>
<td>CRFs + BMD</td>
<td>1.18 (1.12-1.24)</td>
<td>1.23 (1.09-1.38)</td>
<td>1.20 (1.14-1.26)</td>
</tr>
</tbody>
</table>

* BMI, Previous fracture, smoking, glucocorticoids, RA, secondary osteoporosis and alcohol use

E. McCloskey, et al. 2014
**TBS FRAX Meta-Analysis:**

*Gradients of Risks per SD change in risk score*

<table>
<thead>
<tr>
<th>Age</th>
<th>TBS only</th>
<th>Clinical risk factors + BMD</th>
<th>Clinical risk factors + BMD + TBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip fracture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1.51 (0.89 - 2.55)</td>
<td>4.03 (2.01 - 8.10)</td>
<td>5.09 (2.45 - 10.55)</td>
</tr>
<tr>
<td>60</td>
<td>1.46 (1.01 - 2.11)</td>
<td>3.46 (2.13 - 5.62)</td>
<td>4.90 (2.80 - 8.56)</td>
</tr>
<tr>
<td>70</td>
<td>1.41 (1.12 - 1.77)</td>
<td>2.97 (2.23 - 3.97)</td>
<td>4.72 (3.06 - 7.26)</td>
</tr>
<tr>
<td>80</td>
<td>1.36 (1.18 - 1.57)</td>
<td>2.55 (2.14 - 3.05)</td>
<td>4.54 (3.06 - 6.74)</td>
</tr>
<tr>
<td>90</td>
<td>1.31 (1.06 - 1.62)</td>
<td>2.19 (1.66 - 2.90)</td>
<td>4.37 (2.73 - 7.00)</td>
</tr>
</tbody>
</table>

| Other MOP fractures | | | |
| 50  | 1.54 (1.18 - 2.00) | 1.56 (1.18 - 2.05) | 1.62 (1.25 - 2.10) |
| 60  | 1.51 (1.26 - 1.79) | 1.52 (1.26 - 1.84) | 1.58 (1.33 - 1.88) |
| 70  | 1.47 (1.32 - 1.64) | 1.49 (1.30 - 1.69) | 1.54 (1.40 - 1.70) |
| 80  | 1.44 (1.29 - 1.61) | 1.45 (1.28 - 1.65) | 1.50 (1.37 - 1.64) |
| 90  | 1.41 (1.18 - 1.68) | 1.42 (1.18 - 1.70) | 1.46 (1.25 - 1.71) |

*EV McCloskey et al. on behalf of the FRAX meta-analysis working group – 2015*
International recommendations: « FRAX Adjusted for TBS »

• FRAX Group Study Outcome:
  • TBS has a role in a combination model with FRAX to reclassify patients at risk, and especially for those considered at intermediate risk likely to switch from one side to the other of the intervention threshold.

• Eugene McCloskey Quote in the IOF Press Release – April 2014:
  • “By fine tuning the information provided by FRAX, TBS adjusted FRAX gives clinicians more precise information that can aide them in making informed treatment decisions within the course of a clinical assessment.”

• Available online on Sheffield calculation tool since April 15th; www.Shef.ac.uk/FRAX

1 (Model): “Adjust fracture probability by Trabecular Bone Score”, E.V. McCloskey et al. CTI 2015
2 (Validation): “A meta-analysis of trabecular bone score in fracture risk prediction and its relationship to FRAX”, E.V. McCloskey et al. , JBMR 2015
## Table 3. Gradient of Risk (Hazard Ratio per 1 SD) for the Association Between the Outcome of Major Osteoporotic Fracture and TBS or FRAX Probability Adjusted for Time Since Baseline and Age and Additionally Adjusted for Each Other, and FRAX Probability Incorporating TBS Adjustment Factor

<table>
<thead>
<tr>
<th></th>
<th>Men + women</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GR (95% CI)</td>
<td>GR (95% CI)</td>
<td>GR (95% CI)</td>
</tr>
<tr>
<td>TBS adjusted for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time since baseline and age</td>
<td>1.44 (1.35–1.53)</td>
<td>1.50 (1.36–1.66)</td>
<td>1.40 (1.30–1.52)</td>
</tr>
<tr>
<td>+FRAX probability&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.32 (1.24–1.41)</td>
<td>1.35 (1.21–1.49)</td>
<td>1.31 (1.21–1.42)</td>
</tr>
<tr>
<td>FRAX probability&lt;sup&gt;a&lt;/sup&gt; adjusted for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time since baseline and age</td>
<td>1.70 (1.60–1.81)</td>
<td>1.80 (1.64–1.98)</td>
<td>1.63 (1.50–1.77)</td>
</tr>
<tr>
<td>+TBS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.69 (1.50–1.71)</td>
<td>1.69 (1.54–1.87)</td>
<td>1.54 (1.41–1.68)</td>
</tr>
<tr>
<td>TBS-adjusted 10-year probability&lt;sup&gt;b&lt;/sup&gt; adjusted for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time since baseline and age</td>
<td>1.76 (1.65–1.87)</td>
<td>1.86 (1.70–2.04)</td>
<td>1.66 (1.55–1.82)</td>
</tr>
</tbody>
</table>

## Table 4. Gradient of Risk (Hazard Ratio per 1 SD) for the Association Between the Outcome of Hip Fracture and TBS or FRAX Probability Adjusted for Time Since Baseline and Age and Additionally Adjusted for Each Other, and FRAX Probability Incorporating TBS Adjustment Factor

<table>
<thead>
<tr>
<th></th>
<th>Men + women</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GR (95% CI)</td>
<td>GR (95% CI)</td>
<td>GR (95% CI)</td>
</tr>
<tr>
<td>TBS adjusted for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time since baseline and age</td>
<td>1.44 (1.28–1.62)</td>
<td>1.47 (1.23–1.75)</td>
<td>1.42 (1.21–1.67)</td>
</tr>
<tr>
<td>+FRAX probability&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.28 (1.13–1.45)</td>
<td>1.27 (1.06–1.53)</td>
<td>1.29 (1.09–1.52)</td>
</tr>
<tr>
<td>FRAX probability&lt;sup&gt;a&lt;/sup&gt; adjusted for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time since baseline and age</td>
<td>2.22 (2.00–2.47)</td>
<td>2.34 (2.02–2.72)</td>
<td>2.11 (1.81–2.45)</td>
</tr>
<tr>
<td>+TBS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.13 (1.91–2.39)</td>
<td>2.20 (1.95–2.66)</td>
<td>1.69 (1.70–2.02)</td>
</tr>
<tr>
<td>TBS-adjusted 10-year probability&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time since baseline and age</td>
<td>2.25 (2.03–2.51)</td>
<td>2.37 (2.04–2.75)</td>
<td>2.14 (1.84–2.49)</td>
</tr>
</tbody>
</table>

GR = gradient of risk; TBS = trabecular bone score; CI = confidence interval.
<sup>a</sup>Ten-year probability of hip fracture calculated using BMD with FRAX.
<sup>b</sup>Ten-year hip fracture probability adjusted using adjustment factor for TBS derived from McCloskey and colleagues.<sup>32</sup>
TBS data can be used to adjust FRAX
Lower TBS increases calculated risk, higher TBS reduces it

Two patients (age 50 and 80) with same 10-year risk (21%)
Two patients (age 50 and 80) with same 10-year risk (4.6%)

McCloskey EV, et. al, Calcif Tissue Int, 2015; DOI 10.1007/s00223-015-9980-x
Used with permission
Proportion reclassified and NRI for individual FRAX intervention criteria

<table>
<thead>
<tr>
<th></th>
<th>MOF 20%</th>
<th>Hip 3% (^a)</th>
<th>Age-specific</th>
<th>Canada</th>
<th>NOGG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reclassification</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>All subjects</em></td>
<td>2.6%</td>
<td>2.8%</td>
<td>4.5%</td>
<td>2.3%</td>
<td>2.8%</td>
</tr>
<tr>
<td><em>Close to cutoff</em> (^b)</td>
<td>17.5%</td>
<td>17.9%</td>
<td>25.3%</td>
<td>15.4%</td>
<td>14.6%</td>
</tr>
<tr>
<td><strong>NRI total all ages</strong></td>
<td>+1.1%(^\ast\ast)</td>
<td>+1.8%(^\ast\ast\ast)</td>
<td>+0.7%</td>
<td>+0.8%(^\ast)</td>
<td>+1.1%(^\ast\ast)</td>
</tr>
</tbody>
</table>

\(^a\) For hip fracture prediction. \(^b\) MOF 20%±5\%[absolute], HF 3%±1\%[absolute], age-specific±20\%[relative]. NOGG = UK National Osteoporosis Guidelines Group.

* P<0.05, ** P<0.01, *** P<0.001
Since the end of 2014, TBS is included in German osteoporosis guidelines (DVO) as a clinical risk factor.
A 73-year-old woman with a BMD T-score of -2.4 and without any other clinical risk factor should not be treated (as presented in the table below, green highlight). This patient has a L1-L4 TBS of 1.050 (TBS Z-score of -2).

Based on the DVO recommendations, this patient is now eligible for treatment (as presented in the table below, red highlight).

**TBS into International Guidelines**

**German DVO**

- TBS Z-score of -2 => T-score adjustment by TBS, by adding +0.5
- TBS-modified T-score = -2.9 => Treatment

<table>
<thead>
<tr>
<th>Lebensorter in Jahren</th>
<th>T-Score (Nur anwendbar auf DXA-Werte. Die Wirksamkeit einer medikamentösen Therapie ist für periphere Frakturen bei einem T-Score &gt; -2.0 nicht belegt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frau</td>
<td>Mann</td>
</tr>
<tr>
<td>50-60</td>
<td>60-70</td>
</tr>
<tr>
<td>60-65</td>
<td>70-75</td>
</tr>
<tr>
<td>65-70</td>
<td>75-80</td>
</tr>
<tr>
<td>70-75</td>
<td>80-85</td>
</tr>
<tr>
<td>&gt;75</td>
<td>&gt;85</td>
</tr>
</tbody>
</table>

* Alternative Risikomodellierungen können bei Bedarf vergleichend zu Rate gezogen werden; siehe Langfassung
Can TBS be used to monitor changes across time and particularly for treatments follow-up?

Differential effect upon the molecule
Efficacious therapies for osteoporosis differ in the extent to which they influence the TBS.

- **Teriparatide (20µg)** [1]:
  - Highest TBS changes after 24 months of treatments

- **Teriparatide (20µg)** [2]:

- **Denosumab** [2]:
  - Almost no TBS change as expected under Bisphosphonate

- **Risedronate** [2]:

- **Alendronate** [2]:

- **Zoledronic Acide** [3]:

- **Bisphosphonates** [4]:

% of change at 2 years

TBS change above LSC

- 7 studies identified, low N
- 5 studies of osteoporosis treatment in postmenopausal women (1 in men); 2 in management of breast cancer
- Efficacious therapies for osteoporosis differ in the extent to which they influence the TBS
- BMD & TBS measuring different bone properties, % of changes cannot be compared
- Percentage of individual exceeding TBS LSC at 95% CI:

  - TERIPARATIDE [1]: 60%
  - DENOSUMAB [2]: 42%
  - ZOLEDRONIC ACID [3]: 33%
  - BISPHOSPHONATE [1]: 12%

- No data yet on fracture reduction related to TBS changes
TBS High Added Value in Case of Secondary osteoporosis
Despite the relative small number of patients evaluated, TBS has been shown to be associated with fractures in:

- diabetes,
- primary hyperparathyroidism,
- rheumatoid arthritis,
- adrenal incidentaloma,
- chronic kidney disease,
- in individuals on longterm GC therapy.

Moreover, TBS is reduced in patients with ankylosing spondylitis, and improves after the treatment of endocrinological conditions related to reduced bone mass, such as Cushing’s disease, and primary hyperparathyroidism.

Effects of GCs on bone health

- Cross sectional study
- 416 subjects aged 40 years and over who received GCs (≥5 mg/day, for ≥3 months)
- 1104 matched control subjects: gender, age (±3 yrs) and BMI (± 2kg/m²)
- Matching 1:1 for men (n= 72) and 1:3 for women (n=344)
- Control subjects were included if they had an aBMD with a Z-score from -2 to +2 SD
- Any low trauma fracture was considered for this study except for fractures of fingers, toes and skull.
Effects of GCs on bone health

1520 males & Females ≥ 40 ans, USA

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th></th>
<th>GCs treated group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without fracture (n=959)</td>
<td>With fracture (n=145)</td>
<td>p</td>
<td>Without fracture (n=348)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>63.1±9.7</td>
<td>66.1±11.2</td>
<td>**</td>
<td>63±10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spine aBMD (g/cm²)</td>
<td>1.06±0.104</td>
<td>1.03±0.093</td>
<td>**</td>
<td>1.063±0.166</td>
</tr>
<tr>
<td>Total Femur aBMD (g/cm²)</td>
<td>0.889±0.112</td>
<td>0.872±0.106</td>
<td>ns</td>
<td>0.884±0.137</td>
</tr>
<tr>
<td>Femoral neck aBMD (g/cm²)</td>
<td>0.84±0.105</td>
<td>0.815±0.104</td>
<td>a</td>
<td>0.832±0.126</td>
</tr>
<tr>
<td>Spine TBS (-)</td>
<td>1.30±0.112</td>
<td>1.27±0.125</td>
<td>**</td>
<td>1.276±0.134&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spine TBS Z-score (SD)</td>
<td>0±1.1</td>
<td>-0.1±1.3</td>
<td>ns</td>
<td>-0.3±1.3&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Exercise (%)</td>
<td>82.5</td>
<td>84.1</td>
<td>ns</td>
<td>84.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical Risk Factors</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Menopausal Women (%)</td>
<td>88.5</td>
<td>97.2</td>
<td>**</td>
<td>77.9&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rheumatoid arthritis (%)</td>
<td>2.5</td>
<td>8.3</td>
<td>**</td>
<td>23.3&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kidney ill (%)</td>
<td>0.1</td>
<td>0.7</td>
<td>ns</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Leib E. Osteoporos Int 2015
A TBS decrease is observed even from low dose of GCs (5mg/day) while no change in BMD values is observed in comparison with the reference values.
Is TBS Helpful in Diabetes?
29,407 women ≥50 years with baseline DXA

<table>
<thead>
<tr>
<th></th>
<th>Diabetes – No diabetes</th>
<th>Mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar spine BMD (g/cm²)</td>
<td>+0.031</td>
<td>(0.024 : 0.038)</td>
</tr>
<tr>
<td>Femoral neck BMD (g/cm²)</td>
<td>+0.012</td>
<td>(0.007 : 0.016)</td>
</tr>
<tr>
<td>Trochanter BMD (g/cm²)</td>
<td>+0.008</td>
<td>(0.003 : 0.013)</td>
</tr>
<tr>
<td>Total hip BMD (g/cm²)</td>
<td>+0.019</td>
<td>(0.014 : 0.025)</td>
</tr>
<tr>
<td>Lumbar spine TBS (unitless)</td>
<td>-0.051</td>
<td>(-0.056 : -0.046)</td>
</tr>
</tbody>
</table>

ANCOVA adjusted for age, BMI, glucocorticoids, prior major fracture, rheumatoid arthritis, COPD, alcohol abuse and osteoporosis therapy.

Leslie WD et al. JCEM 2013.
TBS is More Sensitive Than BMD to Diabetes-Related Fracture Risk

Les TBS predicted fractures in those with diabetes (adjusted HR 1.27, 95% CI 1.10-1.46) and without diabetes (HR 1.31, 95% CI 1.24-1.38).

Odds ratios (95% CI bars) for lowest vs highest tertile according to presence of diabetes (adjusted for age, BMI, osteoporosis therapy, glucocorticoids, prior fracture, rheumatoid arthritis, COPD, alcohol abuse).

Leslie WD et al. JCEM 2013.
Bone quality assessment in type 2 diabetes mellitus

In T2DM, TBS is lower and associated with poor glycemic control. Abnormal trabecular microarchitecture may help explain the paradox of increased fractures at a higher BMD in T2DM.

Practically
TBS > 1.310 : normal
1.230 < TBS < 1.310 : partially degraded
TBS < 1.230: degraded
Caucasian Women, 58 yrs

Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

Country: UK
Name/ID:

Country: UK
Name/ID:

Questionnaire:

1. Age (between 40 and 90 years) or Date of Birth
   Age: 58
   Date of Birth: Y: __ M: __ D: __

2. Sex
   ○ Male ○ Female

3. Weight (kg)
   65

4. Height (cm)
   160

5. Previous Fracture
   ○ No ○ Yes

6. Parent Fractured Hip
   ○ No ○ Yes

7. Current Smoking
   ○ No ○ Yes

8. Glucocorticoids
   ○ No ○ Yes

9. Rheumatoid arthritis
   ○ No ○ Yes

10. Secondary osteoporosis
    ○ No ○ Yes

11. Alcohol 3 or more units/day
    ○ No ○ Yes

12. Femoral neck BMD (g/cm²)
    T-Score: -2.3

BMI: 25.4
The ten year probability of fracture (%)
with BMD

- Major osteoporotic: 9.1
- Hip Fracture: 3.1

View NOGG Guidance

If you have a TBS value, click here: Adjust with TBS
Caucasian Women, 58 yrs

Intervention Threshold

Major Fracture - 10 year fracture probability

Hip - 10 year hip fracture probability
Caucasian Women, 58 yrs

FRAX adjusted for TBS

Country: UK
Name/ID: N/A
Age: 58
Sex: Female
BMI (kg/m²): 25.4

Please enter the Trabecular Bone Score to compute the ten year probability of fracture adjusted for TBS

Lumbar Spine TBS: 1.16
Calculate

Attention: TBS values are accurate only for patients (women and men) with a BMI in the range [15 – 37 kg/m²]

The 10 year probability of fracture (%)
Adjusted for TBS

Major Osteoporotic Fracture: 12
Hip Fracture: 4

00000026
Individuals with fracture risk assessed since 1st March 2015
Caucasian Women, 58 yrs

Graphs

Intervention Threshold

Major Fracture - 10 year fracture probability

Hip - 10 year hip fracture probability

TBS adjusted FRAX

TBS adjusted FRAX

[Graphs showing intervention thresholds for major fracture and hip fracture probability]
Caucasian Women, 58 yrs

FRAX adjusted for TBS

Calculation tool

Country: UK
Name/ID: N/A
Age: 58
Sex: Female
BMI (kg/m²): 25.4

Please enter the Trabecular Bone Score to compute the ten year probability of fracture adjusted for TBS.

Lumbar Spine TBS: 1.47

Attention: TBS values are accurate only for patients (women and men) with a BMI in the range [15 – 37 kg/m²]

The 10 year probability of fracture (%)
Adjusted for TBS

Major Osteoporotic Fracture: 7
Hip Fracture: 2

00000027
Individuals with fracture risk assessed since 1st March 2015
Caucasian Women, 58 yrs

Graphs

Intervention Threshold

Major Fracture - 10 year fracture probability

Hip - 10 year hip fracture probability

- Treat
- Lifestyle advice and reassure
Neil 'case...
Treatment category switch based on FRAX adjusted for TBS

• Jane Doe is a 65 year-old white female who is concerned about her mother recently fell and sustained a hip fracture. Her mother had previously 3 VF, the first of which occurred at age 68. Mrs Does is generally healthy taking only a statin for hyperlipidemia. Her diet provides ~1000 mg of calcium and she takes 1000 IU of suppl. Vit D3 daily. Shes does not smoke, drinks one glass of wine daily and walks for abut 30 minutes 3 to 5 times a week. Her menopause was at age 48 and she never received HRT. She has no personal history of fragility fracture, history of RA or GC use.

• Her physical examination is unrevealing; Height 158 and weight 57 kg

• Laboratory evaluation included serum calcium, creatinine, phosphorous, PTH and 25 (OH)D, all of which were normal

• Osteopenic BMD: Spine L1- 4 T-score = -1,8 & Femoral neck T-score = -1,7

• Degraded structure: Spine L1- 4 TBS = 1,120
Neil's case...
Treatment category switch based on FRAX adjusted for TBS

Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

Country: US (Caucasian)  Name/ID: 

Questionnaire:
1. Age (between 40 and 90 years) or Date of Birth
   Age: 65  Date of Birth: ____________
2. Sex
   Male  Female
3. Weight (kg)  57
4. Height (cm)  158
5. Previous Fracture
   No  Yes
6. Parent Fractured Hip
   No  Yes
7. Current Smoking
   No  Yes
8. Glucocorticoids
   No  Yes
9. Rheumatoid arthritis
   No  Yes
10. Secondary osteoporosis
    No  Yes
11. Alcohol 3 or more units/day
    No  Yes
12. Femoral neck BMD (g/cm²)
    GE-Lunar  0.805  T-score: -1.7

BMI: 22.8
The ten year probability of fracture (%) with BMD
   Major osteoporotic  17
   Hip Fracture  1.2

If you have a TBS value, click here: Adjust with TBS
Neil 'case...
Treatment category switch based on FRAX adjusted for TBS

Calculation tool

Country: US (Caucasian)
Name/ID: -
Age: 65
Sex: Female
BMI (kg/m²): 22.8

Please enter the Trabecular Bone Score to compute the ten year probability of fracture adjusted for TBS

Lumbar Spine TBS: 1.12
Calculate

Attention: TBS values are accurate only for patients (women and men) with a BMI in the range [15 – 37 kg/m²]

The 10 year probability of fracture (%)
Adjusted for TBS

Major Osteoporotic Fracture: 21
Hip Fracture: 1.9

00005932
Individuals with fracture risk assessed since April 15, 2015
Neil 'case...
Treatment category switch based on FRAX adjusted for TBS

- In this individuals, the estimated 10 year probability of major OP related fracture is 17%. Based on this, she does not meet current NOF guidelines for therapy.
- However, her TBS is very low (classification: degraded microarchitecture)
- The 10 years probability of major osteoporotic related fracture adjusted for TBS is 21%. Based upon this, she does meet treatment guidelines
Berengere 'case…
Impact of GC on TBS

- Jane Doetoo is a 58 year-old white female with Polyarthritis Rheumatoid for the last 25 years (erosive positive). She had 2 total knees and 1 elbow implants.

- She is receiving classical PR treatment: Methotrexate & Atemra

- Osteopenic BMD: Spine L1-4 T-score = -1.3 & Femoral neck T-score = -1.7

- Normal/partially degraded structure: Spine L1-4 TBS = 1,311

- FRAX is for MOF at 11% and 1.3% for hip fracture probability – Adjusted for TBS: 11% and 1.2%, respectively

2 years after, Jane had a major PR flare
She then received daily dose of gluco-corticoid (15 mg), then 10 then 5
RAPPORTE DE SUIVI TBS AU RACHIS L1-L4

Graphique de suivi TBS
Population de référence : Européenne

GC Initiation

<table>
<thead>
<tr>
<th>Date examen</th>
<th>Age</th>
<th>TBS L1-L4</th>
<th>DMO</th>
<th>Var. TBS/base</th>
<th>Var. TBS/précédent</th>
<th>Var. TBS/an</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/02/2011</td>
<td>58</td>
<td>1.279</td>
<td>0.946</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>08/15/2013</td>
<td>60</td>
<td>1.311</td>
<td>0.942</td>
<td>2.5%</td>
<td>2.5%</td>
<td>1.3%</td>
</tr>
<tr>
<td>08/17/2015</td>
<td>62</td>
<td>1.213</td>
<td>0.959</td>
<td>-5.1% *</td>
<td>-7.5% *</td>
<td>-3.7% *</td>
</tr>
</tbody>
</table>
No bone specific treatment was given…

She ended up with hip fracture from standing height fall!!
Conclusions
Are we taking care of osteoporosis OR do we want to prevent osteoporotic fracture?
Fracture Risk Assessment / Prevention…. Not a simple matter…

Nutrition (proteins, calcium)
History of parental fracture
**Excess Alcohol, Tabaco intake**
Glucocorticoid
**Malabsorption**
Chronic or inflammatory diseases
**Oestrogen deficiency**

Age and Sex
Past fracture
Low physical activity
Low BMI
Low Vitamin D

History of falls
**Lack of Social interactions**
Inappropriate surrounding
Unbalance, muscle weakness
Dementia
**Impaired cognition & Vision**
Drugs

Osteoporosis
Bone strength

- Prevention
  - Screening
  - Treatment

Fall conditions
Propensity to fall

- Fall prevention
  - Minimising the consequences of fall

Interdisciplinary Patient Care

Neuro-nutritio-musculo-skeletal Interfaces

Sarcopenia & muscle deteriorations

Primary & secondary bone diseases

Primary neurological diseases with effect to muscle

Nutrition

neuro

muscle

skeletal

D. Hans 2014
DXA 5 in 1

- OP Diagnostic (T-score)
- Treatment selection
- Treatment follow-up
- Fracture prediction (FRAX®)

Fracture prediction (additional CRF)

BMD Complement
- Help in better treatment selection
- Fine tune individual fracture risk prediction (Adjusted FRAX…)

Muscle weakness
Fall related
BMI Equivalent

Body Composition

Clinical OP Diagnosis
Weight on risk level

Morphometry

Macro-Architecture

Micro-Architecture
You have to own TBS to make appropriate clinical judgement in the context of an individual patient