TBS (Trabecular Bone Score™) Payer Dossier

Prepared by

August 2022

Purpose of this Document

To educate and provide supporting evidence for payer coverage of Trabecular Bone Score (TBS). Included are:

- Demonstration of the Clinical Need for TBS in assessment of fracture risk
- Evidence of Clinical Utility
- A subset of Clinical Evidence to support payer coverage
- National and International Medical Organizations with Guidelines supporting use of TBS

Notables:

- TBS has been used by more than 35,000 clinicians worldwide for more than 10 years in routine clinical practice.
- There are more than 900 peer reviewed publications on TBS

Clinical Need

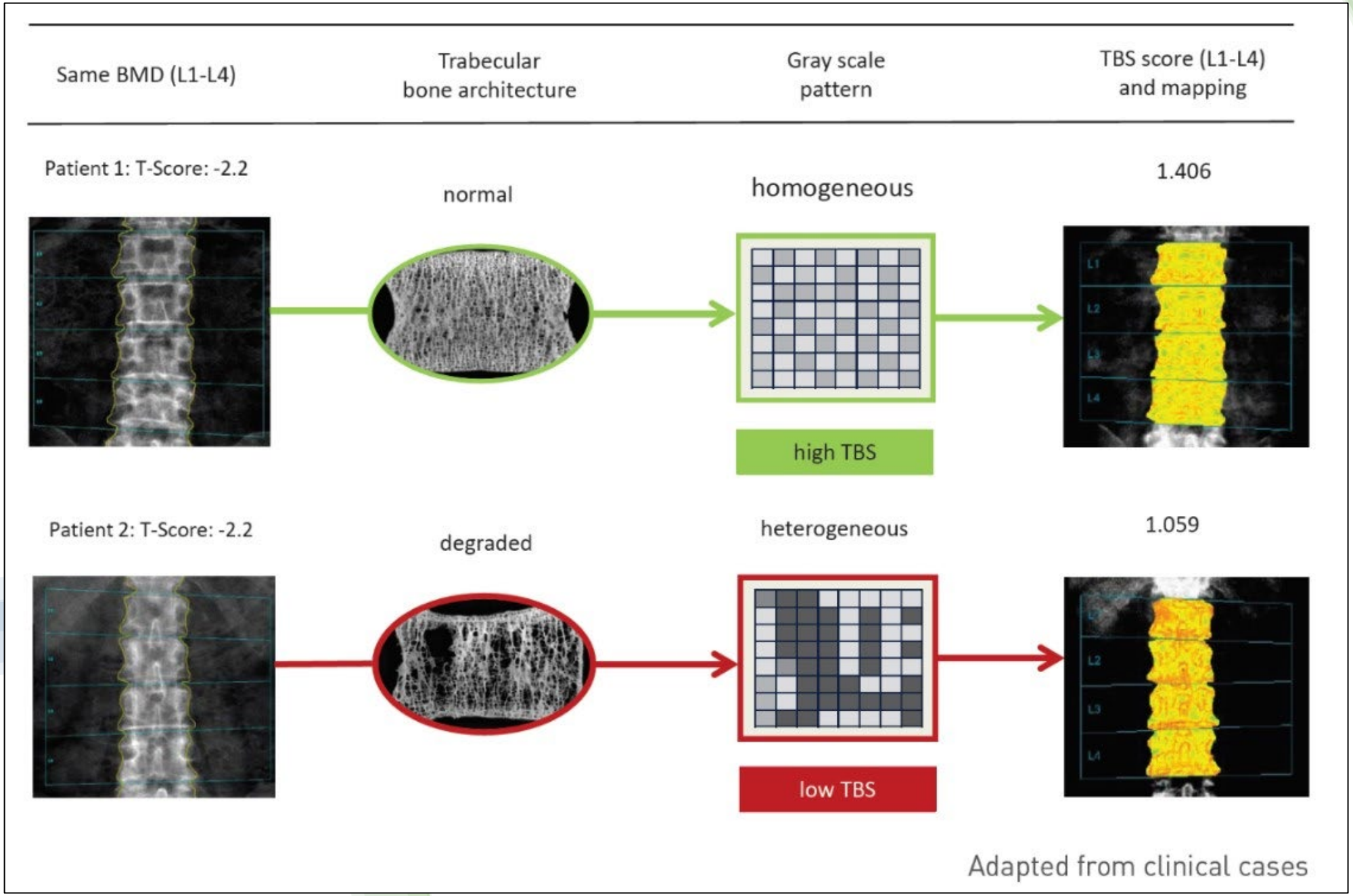
In the US, osteoporosis affects almost 20% of women and 5% of men aged 50 and over. While osteoporosis is typically associated with postmenopausal women, other health conditions such as rheumatoid arthritis, diabetes, cancer, and Crohn's disease can also cause bone loss as well as medications like steroids and proton pump inhibitors.

According to the Bone Health and Osteoporosis Foundation (formerly National Osteoporosis Foundation), the disease is responsible for 2 million broken bones and $19B in costs each year.

The World Health Organization defines osteoporosis as decreased bone density (quantity) and deterioration of microarchitecture (quality).

While bone mineral density (BMD) has long been used in the diagnosis and management of osteoporosis, the information does not provide the full picture of fracture risk. When using BMD T-score alone, it has been shown that up to 50% of patients not considered osteoporotic are still fracturing. TBS in combination with BMD has been shown to be a more complete predictor of fracture risk and can help identify 30% more patients at high risk of fracture.

Sources: CDC (link), MediMaps (link), Siris, ES, et al. (link), Hans, D. et al. (link)



Shown here, two patients with the same BMD may have different fracture risk based on their trabecular bone architecture

Trabecular bone score (TBS) Overview

TBS is an advanced imaging software for bone densitometers (DXA). It enhances the ability to predict osteoporotic fracture risk. The result - expressed as a Trabecular Bone Score (TBS) - derives from a patented algorithm that evaluates pixel gray-levels and spatial variations in the AP spine DXA scan, providing an indirect, yet highly correlated, index of bone microarchitecture that is mostly independent of bone mineral density (BMD), clinical risk factors and FRAX®

TBS is a measurement of the structural condition of the bone microarchitecture. It is strongly correlated with the number of trabeculae and their connectivity and negatively with the space between trabeculae. A high TBS value means that microarchitecture bone is dense, well connected with little spaces between trabeculae. Conversely, a low TBS value means that the microarchitecture of bone is incomplete and poorly connected with wide spaces between trabeculae.

TBS predicts the risk of major osteoporotic fracture independently of bone mineral density (BMD) and clinical risk factors. The TBS score is complementary to DXA and helps physicians better classify patients for risk of fracture.

TBS Report

Image Center of Geneva

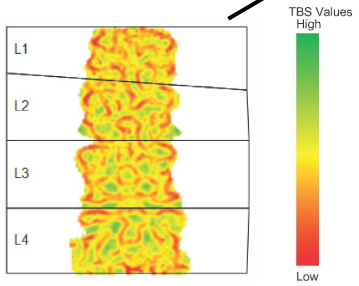
Dr. Strangelove
Rue 66
Geneva - Canton of Geneva - 1234 - ✆: +1 1234567890

Patient:	Jane, Doe		
Patient ID:	1000	Date of birth - Age:	01/07/1940 - 81 years
Height - Weight - BMI:	150.7 cm - 58.3 kg - 25.7 kg/m²	Gender - Ethnicity:	Female - White
Referring physician:	Dr. Strangelove	Acquisition date:	13/01/2022

BONE HEALTH REPORT

Not for diagnostic use due to: DXA system not calibrated

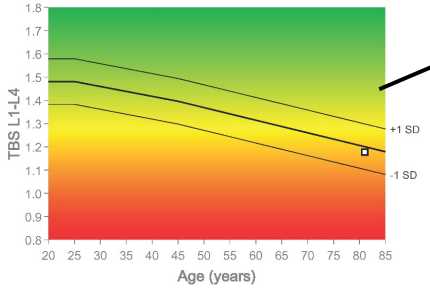
1 TBS Mapping



Non-diagnostic image

2 TBS Spine Results

TBS L1-L4 = 1.178 - Degraded microarchitecture



Reference population: USA (NHANES / Medimaps) - White

3 Skeletal Status Assessment

Osteoporosis is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture.[1]

The TBS is derived from the texture of the DXA image and has been shown to be related to bone microarchitecture and fracture risk. It provides information independent of BMD.

For purpose of clarity, "Bone Resilience Index" is defined as the combination of BMD T-score and TBS categories. The Bone Resilience Index zones are established based upon level of fracture risk.[2]

TBS** \ BMD T-score*	Normal	Osteopenia	Osteoporosis
Normal			
Partially degraded			
Degraded		☐	

* BMD T-score is the min value of spine, total hip and femoral neck
** Spine TBS L1-L4 Normal microarchitecture > 1.31; Degraded ≤ 1.23

Normal	Moderate	Low	Severely low

Color coded Bone Resilience Index zones based on Fracture Risk[2]

4 Therapeutic Decision Tools

The FRAX® 10-year probability of fracture:

Type of Fracture	Risk	Risk adjusted for TBS*
Major Osteoporotic	19 %	24 %
Hip	8.5 %	9.7 %

* Validated only for Caucasian and Asian women and men [3]. Refer to local guidelines before using these values.

Reported Risk factors beside BMD: glucocorticoids

The BMD T-score:

Bone Site	BMD T-score	BMD T-score adjusted for TBS*
Spine	-2.3	-2.4
Femoral Neck •>	-2.2	-2.4
Total Hip •>	-1.2	-1.4

* Validated for Caucasian women only [4]. The greyed cell is the minimum value. The arrow displayed near the hip bone sites represents the hip side of the exam : <• for left hip, •> for right hip.

TBS osteo

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Local TBS values are displayed using a color scale where values representing a well-structured cancellous bone are green and poorly structured ones are red.

Displays TBS value of the selected region. Usually L1-L4..

Using this graph, the physician can compare the TBS value of a patient to that of the normal population.

Results table for all regions of interest and their combinations, for BMD and TBS

Therapeutic Decision Tools combining BMD (quantity) and TBS (quality) of bone health

FRAX adjusted for TBS for improved probability of fracture

BMD T-score adjusted for TBS for improved fracture risk classification

Prepared by ADVI

Image Center of Geneva

Dr. Strangelove
Rue 66
Geneva - Canton of Geneva - 1234 - ✆: +1 1234567890

Patient:	Jane, Doe		
Patient ID:	1000	Date of birth - Age:	01/07/1940 - 81 years
Height - Weight - BMI:	150.7 cm - 58.3 kg - 25.7 kg/m²	Gender - Ethnicity:	Female - White
Referring physician:	Dr. Strangelove	Acquisition date:	13/01/2022

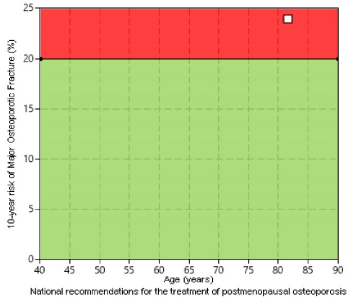
BONE HEALTH REPORT

Not for diagnostic use due to: DXA system not calibrated

5 Detailed Spine Results

Region	TBS	TBS Z-score	BMD (g/cm²)	BMD T-score
L1	1.035	-	0.634	-3.2
L2	1.190	-	0.854	-1.6
L3	1.216	-	0.808	-2.5
L4	1.270	-	0.864	-1.8
L1-L4	1.178	-0.2	0.801	-2.3
L1-L3	1.147	-0.2	0.774	-2.2
L1-L4(L3)	1.165	-0.1	0.799	-2.1
L1-L4(L2)	1.174	-0.1	0.786	-2.4
L2-L4	1.225	-0.3	0.842	-2.2
L1-L2	1.113	0.0	0.752	-2.1
L1-L3(L2)	1.126	-0.2	0.734	-2.5
L1-L4(L2L3)	1.153	0.0	0.774	-2.4
L2-L3	1.203	-0.4	0.829	-2.1
L2-L4(L3)	1.230	-0.3	0.860	-2.0
L3-L4	1.243	-0.3	0.838	-2.4

6 FRAX Curve



7 Conclusion

The Lumbar spine TBS is 1.178 which suggests a degraded microarchitecture compared to reference population.

The patient's associated BMD and TBS values suggest a Low resilience to fracture.

Furthermore, the minimum BMD T-score (either adjusted or not for TBS), positions the patient in the Osteopenia category equivalent.

The patient's FRAX results should be interpreted in regard to the intervention thresholds provided by national medical guidelines.

Final decision regarding diagnostic or therapeutic recommendations should include BMD, TBS, additional clinical risk factors as well as the clinical context of the patient.

8 Notes & References

Date of report generation: 25/08/2022 10:02:10
Date of analysis: 13/01/2022 – TBS iNsight version 3.1.2
DXA: QDR 4500 A #0 – File: PA04112A.p05

1. Consensus Development Conference, Am J Med 94, 646-650 (1994)
2. Adapted from J. Bone Miner. Res. 26, 2762–2769 (2011)
3. Calcif Tissue Int. 96, 500-509 (2015)
4. Adapted from Osteoporos Int. 29, 751-758 (2018)

TBS osteo

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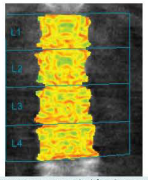
Clinical Value of TBS Report

TBS osteo
bone structure matters

BONE HEALTH REPORT INTERPRETATION STEPS

TBS iNsight™ – powered by medical AI technology

1. TBS Spine Mapping



The image is not intended for diagnosis.

Check your patient positioning and the bone mask

The TBS mapping is the local visual display of the TBS values for each pixel of the DXA image. A low TBS value is represented in red; a high TBS value is represented in green and a medium TBS value in yellow. [1]

It is intended to check patient positioning and the bone mask

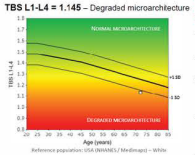
Why is this important?

Patient positioning and bone mask outlining are key for an accurate TBS computation, especially for patient monitoring.

What to do?

- L1-L4 vertebrae are clearly separated at intervertebral spaces.
- Bone edges include all relevant anatomy and exclude the osteophytes.
- Vertebral fractures or artifacts are excluded.

2. TBS Spine Results



Check the bone microarchitecture of the patient

The TBS result computed for the selected vertebrae is plotted onto a reference graph. The graph comprises 2 main parts: The TBS normal values according to age are represented by the thick black line. The thinner lines above and below represent this normative curve +/- 1 SD (standard deviation).

A gradient of different-colored zones representing different status of bone microarchitecture: high TBS values (TBS L1-L4 > 1.31) representing Normal microarchitecture, and low TBS values (TBS L1-L4 ≤ 1.23) representing Degraded microarchitecture.

Why is this important?

With this graph, you can see how the TBS score of the patient compares to the normal population (same age, same gender, same ethnicity) and see if the patient is at high risk of fracture based on the microarchitecture assessment only.

What to do?

Use the colors to assess your patient risk based on the microarchitecture assessment. If TBS is in the:

- Green zone: low risk of fracture, suggesting normal bone microarchitecture.
- Yellow zone: medium risk of fracture, suggesting partially degraded bone microarchitecture.
- Red zone: high risk of fracture, suggesting degraded bone microarchitecture.

3. Fracture Risk Assessment

Osteoporosis is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fractures.[3]

The TBS is derived from the texture of the DXA image and has been shown to be related to bone microarchitecture and fracture risk. It provides information independent of BMD.

TBS **	BMD T-score * Normal	Osteopenia	Osteoporosis
Normal		○	
Partially degraded			
Degraded			

* BMD T-score is the min value of spine, total hip and femoral neck
** Spine TBS L1-L4 Normal microarchitecture > 1.31; Degraded ≤ 1.23

Low risk	Medium risk	High risk	Very High risk

Color coded Bone Health categories based on Fracture Risk[2]

Assess the fracture risk of the patient

A color-coded grid shows the major osteoporotic fracture risk classification based on combined BMD (minimum T-score of spine, total hip and femoral neck) and TBS categories corresponding to 3 tertiles of TBS values [2]. The colors of the different Bone health categories indicate the risk of fracture [1].

Why is this important?

Osteoporosis is "characterized by low bone mass and a microarchitectural deterioration of bone tissue". The BMD is an assessment of the bone mass. When only the BMD is considered, studies have shown that more than 50% of fractures occur in patients with BMD T-score outside the Osteoporosis category[3]. TBS is intended to provide the microarchitecture information that has been missing in the bone densitometry examination. Both TBS and BMD and other clinical risk factors should be considered for an accurate fracture risk assessment.

What to do?

- Check the white dot representing the patient's risk of fracture based on minimum BMD T-score and TBS to identify his/her risk, consequently:
  - Osteopenic or osteoporotic patients with degraded TBS are at high risk (orange) or very high risk (red) of fracture.
  - Normal or osteopenic patients with partially degraded or normal microarchitecture are at medium (yellow) or low (green) risk of fracture.
- Note that Osteopenia and Degraded Microarchitecture may result from a secondary cause of osteoporosis [4].

(1) Hans, D., Goertzen, A.L., Krieg, M.-A., Leslie, W.D., 2011. Bone microarchitecture assessed by TBS predicts osteoporotic fractures independent of bone density: the Manitoba study. J. Bone Miner. Res. 26, 2762–2769. https://doi.org/10.1002/jbmr.499.
(2) The TBS thresholds were defined from analysis of data from 14 prospective clinical studies (including data from: France, Germany, UK, Switzerland, Sweden, Netherlands, Canada, Australia, Hong-Kong and Japan) involving 17,809 men and women aged 40 and older. Osteoporos Int. 29, 751–758 (2018).
(3) Shevroja et al. J Clin Densitom 20, 334–345 (2017).
(4) Ulivieri, F. M. et al. Endocrine 47, 435–448 (2014).

4. Therapeutic Decision Tools

The FRAX® 10-year probability of fracture:

Type of Fracture	Risk	Risk adjusted *
Major Osteoporotic	20%	15%
Hip	0.4%	0.1%

* Adjusted for TBS *. Validated only for Caucasian and Asian women and men. Refer to local guidelines before using these values.
Reported Risk Factors: parent fractured hip, glucocorticoids.

The BMD T-score:

Bone Site	BMD T-score	BMD T-score adjusted *
Spine	-1.3	-0.7
Femoral Neck	-0.4	0.0
Total Hip	-0.6	-0.2

* Adjusted for ethnicity, gender and TBS *. Validated for Caucasian women only.
The greyed cell is the minimum value of the 3 sites, either adjusted or not

This section on the report is optional

Individualize treatments decisions

This section provides information tools that can be used to help you make the most appropriate therapeutic decisions:

- Using FRAX when appropriate:
  - Risk category: displays FRAX probabilities provided by the DXA software
  - Risk adjusted category: displays FRAX probabilities adjusted for TBS, taking into account the status of the trabecular bone microarchitecture in the fracture risk assessment [1]
- Using BMD T-score when appropriate.
  - BMD T-score: displays T-scores computed by the DXA software
  - BMD T-score adjusted: displays T-scores adjusted for TBS for women only. [2]

The adjustment of the T-score is just the application of the equation that is available in the scientific literature [2]. No indication is provided on how to use this adjusted value versus the regular BMD T-score. The formulas to adjust the BMD T-score are explained in the TBS iNsight – Technical Guide. In the BMD T-score column are the BMD T-scores provided by DXA software while BMD T-scores adjusted are BMD T-score adjusted for ethnicity, gender and TBS. The greyed cell is the minimum value of the 3 sites, either adjusted or not.

Why is this important?

Different drugs (anabolic or anti-resorptive) impact the bone density and the microarchitecture differently. Knowing both the BMD and TBS of your patient, as well as his/her clinical context, is crucial to better understand your patient's bone health and to choose the best beneficial approach.

What to do?

Based on the local guidelines in your country, these new decision tools (based on the FRAX Risk adjusted or the BMD T-score adjusted) may help you estimate the actual risk of fracture of the patient and take the most appropriate decisions regarding therapy.

5. Detailed Spine Results

Region	TBS	TBS Z-score	BMD (g/cm²)	BMD T-score
L1	1.186	-	0.826	-1.8
L2	1.262	-	0.843	-1.8
L3	1.123	-	0.861	-1.7
L4	1.155	-	0.855	-1.7
L1-L4	1.126	-1.06	0.849	-1.7
L1-L3	1.163	-1.11	0.841	-1.8
L1-L2	1.228	-0.97	0.837	-1.8
L1-L4 (L2)	1.123	-1.15	0.861	-1.7
L1-L4 (L3)	1.135	-1.08	0.855	-1.7
L1-L3 (L2)	1.126	-1.07	0.849	-1.8
L2-L4	1.193	-1.03	0.852	-1.7
L2-L3	1.133	-1.16	0.856	-1.7
L2-L4 (L3)	1.228	-1.06	0.863	-1.7
L3-L4	1.129	-1.05	0.858	-1.7
L1-L4 (L2,L3)	1.228	-1.08	0.841	-1.7

This section on the report is optional

Do I need more detail?

This table displays the detail of results that have been calculated by TBS iNsight® according to the regions of interest on the DXA examination, and data pulled from the DXA software.

Why is this important?

Detailed TBS spine results in all vertebrae combinations can be useful to evaluate the impact each vertebra has on the TBS and/or BMD value. It can also help to determine if some vertebrae need to be excluded due to abnormalities.

What to do?

Check these additional results for better interpretation in case some values are questionable and/or you are performing a research study.

6. Conclusion

The lumbar spine TBS is 1.145 which suggests a **normal/partially degraded/degraded** bone microarchitecture compared to reference population.

The patient's associated major osteoporotic fracture risk, based on the combined results of BMD and TBS, is in the **low/medium/high/very high-risk** zone.

Furthermore, the minimum BMD T-score, either adjusted by the gender, the ethnicity and the TBS or not adjusted, positions the patient in the **normal/osteopenia/osteoporosis** category equivalent.

The patient's FRAX results should be interpreted in regard to the intervention thresholds provided by local medical guidelines.

Final decision regarding diagnostic or therapeutic recommendations should include BMD, TBS, additional clinical risk factors as well as the clinical context of the patient.

This section on the report is optional

Make a conclusion and share it with referring doctors

This section displays either conclusions automatically generated by the software based on the TBS and the BMD T-score or a conclusion manually entered by the user.

In the automatic conclusion you can find the summary of the various analyses that have been included in the Bone Health Report. These automatic conclusions have been proposed based on a consensus of experts using TBS iNsight in daily practice.

Why is this important?

Different clinical scenarios will require different solutions. We provide here a summary of the different analyses included in the Bone Health Report to help you get a better understanding of your patient's bone health.

What to do?

Conclusion is key to help the referring physicians better understand the TBS bone health report; that is why we recommend to use the automatic conclusion, if you prefer to customize the wording or the interpretation, you can write your own conclusion from the software interface

7. Notes & References

Date of analysis: 2/17/2020 – TBS version 3.1.0
DXA: QDR Workstation #0 – File: PA20217A.P07

1. Consensus Development Conference, Am J Med 94:646-650 (1994)
2. Adapted from J. Bone Miner. Res. 26, 2762–2769 (2011)
3. Calcif Tissue Int. 96, 500-509 (2015)
4. Adapted from Osteoporos Int. 29, 751-758 (2018)

This section displays the following information: Analysis date, TBS iNsight software version, DXA device model and Serial Number, Name of the DXA file from which the data has been pulled. The references to the scientific literature used in various sections of the report are listed here.

Why is this important?

All Medimaps' statements are based on scientific evidences. You can find the original studies here.

This document is extracted from TBS User Guide TM-011

(1) McCloskey, E.V., Oden, A., Harvey, N.C., Leslie, W.D., Hans, D., Johansson, H., Kanis, J.A., 2015. Adjusting fracture probability by trabecular bone score. Calcif Tissue Int 96, 500–509. https://doi.org/10.1007/s00223-015-9980-x
(2) Leslie, W.D., Shevroja, E., Johansson, H., McCloskey, E.V., Harvey, N.C., Kanis, J.A., Hans, D., 2018. Risk-equivalent T-score adjustment for using lumbar spine trabecular bone score (TBS): the Manitoba BMD registry. Osteoporos Int 29, 751–758. https://doi.org/10.1007/s00198-018-4405-0

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AM-TM-170-001

Prepared by ADVI

Interpreting TBS Values Combined with Bone Density: Use in Patient Management

Prepared by ADVI

TBS is an aid for patient management. All diagnosis and treatment decisions require clinical judgment and consideration of the clinical context of the patient.

The combination of TBS and BMD allows refining the fracture risk analysis, particularly in osteopenic patients. It results the following concept of interpretation table, with risk levels expressed as a number of major osteoporotic fractures per 1'000 women/year:

		Risk Class based on minimum hip or spine BMD T-score		
		Normal	Osteopenia	Osteoporosis
Risk Class based on Spine TBS	≥ 1.310			
	1.230 <> 1.310			
	≤ 1.230			

Adapted from Table 3 in Hans et al. J Bone Miner Res. 2011 Nov;26(11):2762-9

Color coded risk levels for major osteoporotic fracture per 1'000 women per year, based on a ≈30'000 women study.

Color coding based on the following sub-categories of risk:

Color Code	Risk class of Major osteoporotic fracture per 1'000 women per year
	≤ 4
	] 4 - 5]
	] 5 - 7]
	] 7- 10]
	] 10 - 14]
	] 14 - 20]
	> 20

Clinical Utility of TBS

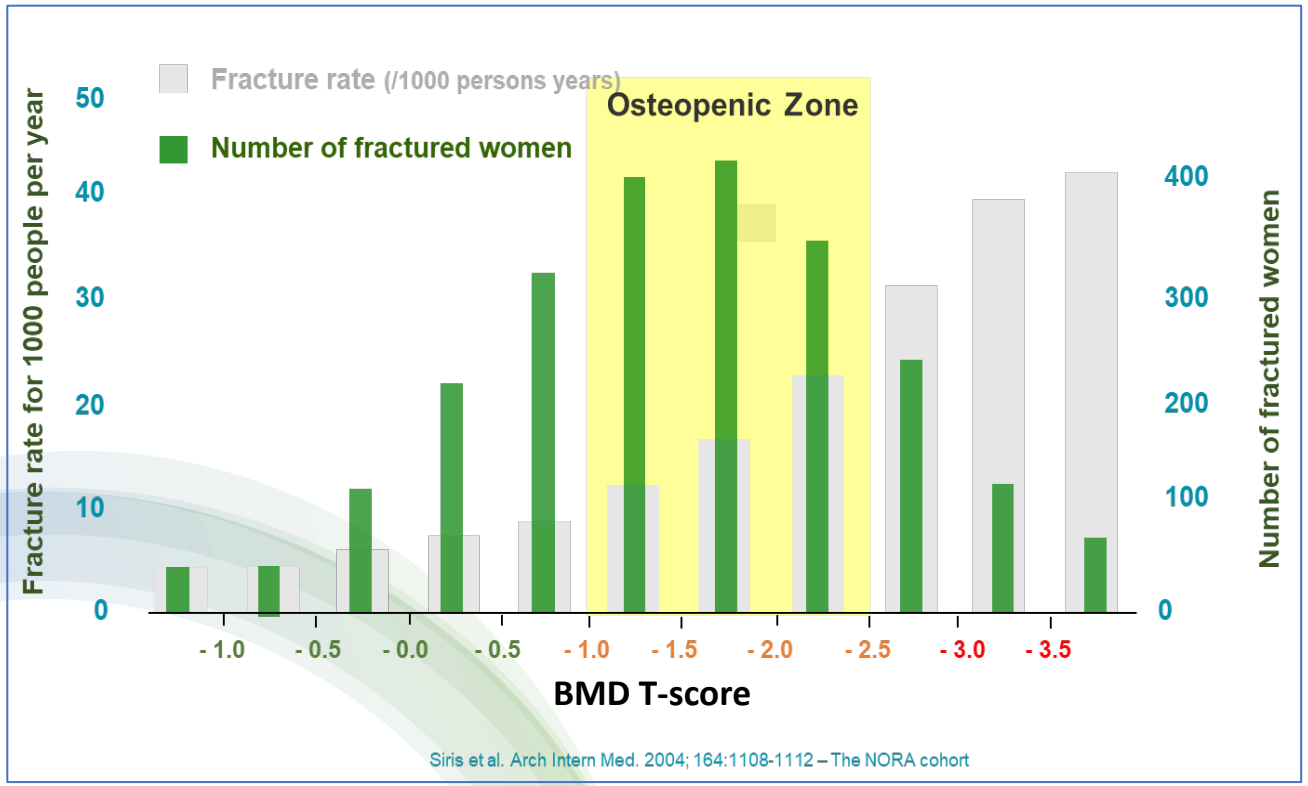
- Clinical studies show that TBS in conjunction with FRAX and BMD data is a better indicator of overall patient fracture risk.
  - TBS data can be used to help determine which patients should receive osteoporosis treatment therapies
  - Appropriate prescribing of osteoporosis treatment therapies provides clinical utility of TBS:
    - Identification of patients that should receive treatment despite non-osteoporotic BMD
    - Avoidance of unnecessary pharmaceutical therapies for patients at low risk of fracture

- TBS has also demonstrated utility in monitoring the effectiveness of bone active agents better than BMD alone.
  - Studies show providing bone active agents can improve bone microarchitecture as assessed by TBS

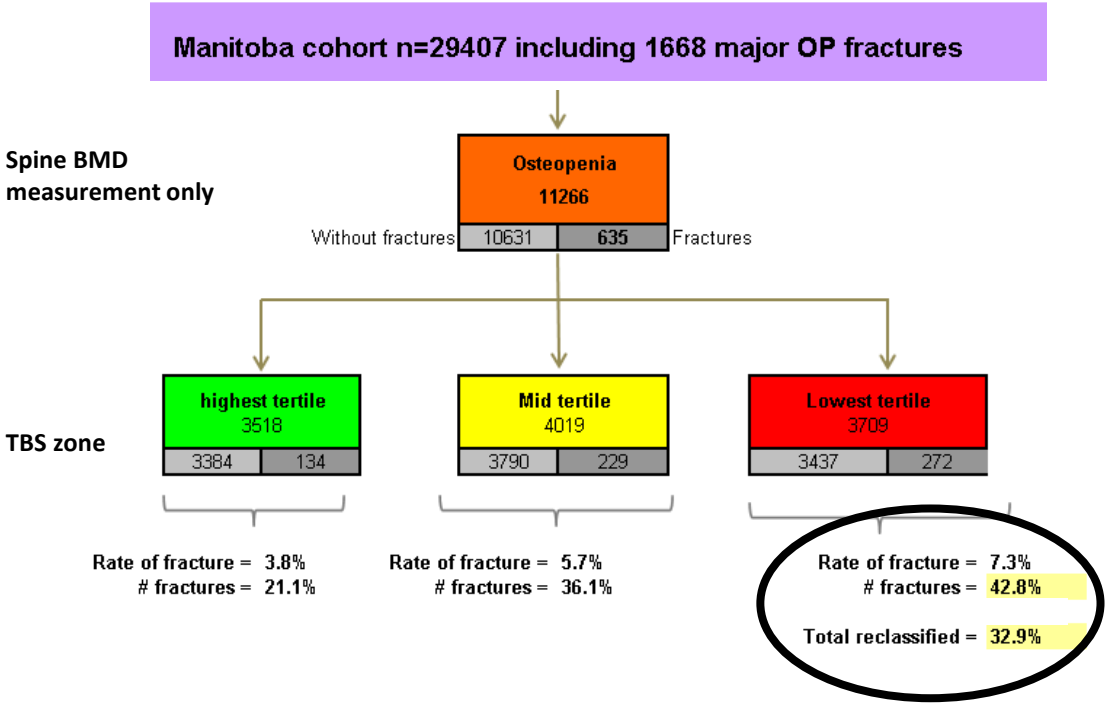
Clinical Utility:
TBS Identifies Patients Missed by BMD Alone

Prepared by ADVI

Data shows >50% of osteoporotic fractures actually occur in patients who are not osteoporotic when characterized by BMD only



Adding TBS in conjunction with BMD measurement reclassifies approximately 30% of cases to the osteoporotic zone



BMD Thresholds

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

Hans et al. JBMR 2011

Clinical Utility: Appropriate Treatment Reduces Fracture Risk by 50%

A wealth of studies exist that show appropriate treatment of osteoporosis reduces fracture risk. By identifying more patients at risk with TBS, the fracture rate due to osteoporosis could be reduced

Citation	Result
Chesnut III, C. H., Skag, A., Christiansen, C., Recker, R., Stakkestad, J. A., Hoiseth, A., Felsenberg, D., Huss, H., Gilbride, J., Schimmer, R. C, Delmas, P. D. Oral Ibandronate Osteoporosis Vertebral Fracture Trial in North America and Europe (BONE). (2004). Effects of oral ibandronate administered daily or intermittently on fracture risk in postmenopausal osteoporosis. *Journal of Bone and Mineral Research*, 19(8), 1241-1249.	Ibandronate – postmenopausal osteoporosis: fracture risk reduction of 62% and 50% depending on medication frequency
Black, D. M., Thompson, D. E., Bauer, D. C., Ensrud, K., Musliner, T., Hochberg, M. C., Nevitt, M. C., Suryawanshi, S., Cummings, S. R. (2000). Fracture risk reduction with alendronate in women with osteoporosis: the Fracture Intervention Trial. *The Journal of Clinical Endocrinology & Metabolism*, 85(11), 4118-4124.	Alendronate – osteoporotic women: relative risk of treated patients between 0.47 and 0.70 depending on fracture type
Lewiecki, E. M., Dinavahi, R. V., Lazaretti-Castro, M., Ebeling, P. R., Adachi, J. D., Miyauchi, A., Gielen, E., Milmont, C. E., Libanati, C., Grauer, A. (2019). One year of romosozumab followed by two years of denosumab maintains fracture risk reductions: results of the FRAME extension study. *Journal of Bone and Mineral Research*, *34*(3), 419-428.	Romosozumab + Denosumab follow-up: relative risk reduction of 66% for new vertebral fractures, 27% for clinical fractures and 21% for non-clinical fractures.
Vestergaard, P., Jorgensen, N. R., Mosekilde, L., & Schwarz, P. (2007). Effects of parathyroid hormone alone or in combination with antiresorptive therapy on bone mineral density and fracture risk–a meta-analysis. *Osteoporosis International*, 18(1), 45-57.	Parathyroid hormone (PTH) alone or combined with antiresorptive therapy (meta-analysis): relative risk between 0.36 (vertebral fractures) and 0.62 (non-vertebral fractures)

Clinical Utility: Monitoring Effectiveness of Osteoporosis Treatment

Use of bone active agents is linked to an improvement in TBS

Citation	Result
Kang T, Park SY, Lee SH, Park JH, Suh SW. Comparison of Denosumab and Zoledronic Acid in Postmenopausal Women With Osteoporosis: Bone Mineral Density (BMD) and Trabecular Bone Score (TBS). J Korean Med Sci. 2022 Apr 4;37(13):e68.	Two groups of postmenopausal women with osteoporosis given either donosumab or zoledronic acid were retrospectively reviewed. After 2-year follow up both groups had statistically significant changes in TBS compared with baseline
N.V. Sandeep, A. Joseph, K.E. Cherian, N. Kapoor, T.V. Paul. Impact of Teriparatide Therapy in Indian Postmenopausal Women with Osteoporosis with Regard to DXA-Derived Parameters. Ther Adv Endocrinol Metab. 2022;13:1-8	Following treatment with teriparatide, significant improvement was observed in the TBS of 51 postmenopausal women at 2 years of follow up. At baseline, 74.4% of participants had existing vertebral fractures. Incident/worsening of vertebral fractures were noted in 7.8% of participants and no new nonvertebral fractures were observed during follow up.

Use of TBS in partnership with FRAX and BMD can lead to improved outcomes for patients and lower costs for health plans by 1) identification of appropriate therapy utilization for the appropriate patients leading to 2) reduction in fracture risk and subsequently 3) reduction in morbidities and mortality

FDA Clearance

510 K Summary

 medimaps group

This summary of the 510(k) Premarket Notification for the medimaps group TBS iNsight software is being submitted in accordance with the requirements of SMDA 1990 and 21 CFR 807.92.

The assigned 510(k) number is : K121716

OCT 5 2012

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Date Prepared:	June, 4, 2012
Device Names:	
Trade/Proprietary Name:	TBS iNsight
Common or Usual Name:	Bone microarchitecture assessment from medical imaging
Device Class	Class II
Classification Name:	21 CFR 892.1170 - Bone Densitometer
Product Code:	KGI

DEVICE DESCRIPTION

TBS iNsight is a software package that provides an estimate of the trabecular bone quality based on analysis of data derived from DEXA examination. The program utilizes a quantitative bone structural algorithm that analyzes the texture of AP spine projection scans from which the Trabecular Bone Score (TBS) is mathematically derived.

The results (TBS) can be used for comparison to a reference database of age-matched controls.

INTENDED USE / INDICATIONS FOR USE

The Med-Imaps TBS iNsight is a software provided for use as a complement to a DEXA analysis. It computes the antero-posterior spine DEXA examination file and calculates a score (Trabecular Bone Score - TBS) that is compared to those of the age-matched controls. The TBS is derived from the texture of the DEXA image and has been shown to be related to bone microarchitecture and fracture risk. This data provides information independent of BMD value; it is used as a complement to the data obtained from the DEXA analysis and the clinical examination (questioning by the clinician about patient history, bioassay of bone resorption markers…).
The TBS score can assist the health care professional in assessment of fracture risk and in monitoring the effect of treatments on patients across time.
Overall fracture risk will depend on many additional factors that should be considered before making diagnostic or therapeutic recommendations. The software does not diagnose disease, or recommend treatment regimens. Only the health care professional can make these judgments.

FDA Indications for Use

Prepared by ADVI

TBS iNsight received FDA 510(k) clearance and is indicated for use as:

- "A complement to DXA analysis and clinical examination. It computes the antero-posterior spine DXA examination file and calculates a score (Trabecular Bone Score - TBS) that is compared to those of the age matched controls. The TBS is derived from the texture of the DXA image and has been shown to be related to **bone microarchitecture**.
- TBS iNsight provides as an option an assessment of 10-year fracture risk. It provides an **estimate of 10-year probability of hip fracture and 10-year probability of a major osteoporotic fracture** (clinical spine, forearm, hip or shoulder fracture). This estimate is based on the WHO's **FRAX® Fracture Risk Assessment Tool, after adjustment for the TBS**. The tool has been validated for Caucasian and Asian men and post-menopausal women between 40 and 90 years old.
- TBS provides information **independent of BMD value**; it is used as a complement to the data obtained from the DXA analysis and the clinical examination (questioning by the clinician about patient history, bioassay of bone resorption markers…).
- The results **can be used by a physician** in conjunction with other clinical risk factors as an aid in the **diagnosis of osteoporosis and other medical conditions leading to altered trabecular bone microarchitecture**, and ultimately in the **assessment of fracture risk.**
- The TBS score can assist the health care professional in **monitoring the effect of treatments on patients across time**."

Clinical Guidelines

Prepared by ADVI

Many national and international societies have included TBS in their recommendations to manage osteoporosis, diabetes, and hyperparathyroidism. A few of those are summarized below:

Society	Link	Recommendation

American Association of Clinical Endocrinologists	Clinical Practice Guidelines for the Diagnosis and Treatment of Postmenopausal Osteoporosis
	Link
		• Diagnosis of osteoporosis in postmenopausal women:
		  • T-score between -1.0 and -2.5 and high FRAX (or if available, TBS-adjusted FRAX) fracture probability based on country-specific thresholds
		  • "Numerous studies have shown that TBS predicts fracture risk independent of BMD and that it enhances fracture risk prediction capabilities of FRAX®. Low TBS values increase FRAX® estimated risk, while high TBS values reduce it. TBS adjustment of FRAX® has been validated in 14 prospective international cohorts"
		• Pharmacologic therapy is strongly recommended for patients based on TBS-adjusted FRAX 10-year probability for major osteoporotic fracture
		  • "In patients with low bone mass (osteopenia), TBS-adjusted FRAX®, which can be included with the DXA printout, can sometimes be the deciding factor in making treatment decisions. TBS may be especially useful in clinical situations, such as type 2 diabetes and primary hyperparathyroidism, where FRAX® without TBS may underestimate fracture risk."

International Osteoporosis Foundation and European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis	European guidance for the diagnosis and management of osteoporosis in postmenopausal women Link	• Trabecular bone score (TBS) may be used as an adjunct to BMD measurements and FRAX in the assessment of fracture risk. • "Low TBS is consistently associated with an increase in both prevalent and incident fractures that is partly independent of both clinical risk factors and areal BMD at the lumbar spine and proximal femur. It can thus be used as an adjunct to BMD measurements and is a software option for densitometers. Studies including a meta-analysis have shown an incremental improvement in fracture prediction when lumbar spine TBS is used in combination with FRAX variables…Thus, TBS is a predictor of fracture risk independently of FRAX and supports the use of TBS to adjust for FRAX probability." • TBS may also have a role in the assessment of fracture risk in some causes of secondary osteoporosis (e.g. diabetes, hyperparathyroidism and glucocorticoid-induced osteoporosis)

Source: Medimaps TBS Guidelines 2022

Clinical Guidelines

Prepared by ADVI

Society	Link	Recommendation

International Osteoporosis Foundation	Diagnosis and management of bone fragility in diabetes: an emerging challenge Link	• TBS is recommended for the management of diabetic patients with non hip or vertebral fracture, or no fracture but with diabetes related clinical risk factors
		  • "TBS was found to be a BMD-independent predictor of fracture and predicted fractures equally well in those with (aHR 1.27, 95% CI 1.10–1.46) and without diabetes (HR 1.31, 95% CI 1.24–1.38)"
		  • "Conventional clinical risk factors (CRFs) can be employed to identify patients with diabetes at increased fracture risk, although risk assessment tools like FRAX do not fully capture these increased risks and thus systematically underestimate the risk of osteoporosis-related fractures in patients with type 2…The TBS adjustment to FRAX will capture some of the excess fracture risk associated with type 2 diabetes"

International Society for Clinical Densitometry	Adult Official Positions link	• TBS can be used in association with FRAX and BMD to adjust FRAX-probability of fracture in postmenopausal women and older men.
		  • "Serial BMD testing in combination with clinical assessment of fracture risk, bone turnover markers, and other factors including height loss and trabecular bone score, can be used to determine whether treatment should be initiated in untreated patients, according to locally applicable guidelines"
		• TBS is associated with major osteoporotic fracture risk in postmenopausal women with type II diabetes.
		• Elective orthopedic and spine surgery patients with the following conditions are at greater risk for impaired bone health and should have DXA testing:
		  • Diabetes mellitus (long term duration of diabetes (>10yrs) and poor control)
		  • Trabecular bone score measurement should be obtained in patients with diabetes, if available.

Source: Medimaps TBS Guidelines 2022

Clinical Evidence Overview (Osteoporosis)

Prepared by ADVI

Citation	Design	Population	Condition	Outcomes
N. Binkley, S.N. Morin, P. Martineau, L.M. Lix, D. Hans, W.D. Leslie. Frequency of normal bone measurement in postmenopausal women with fracture: a registry-based cohort study. *Osteoporos Int*. 2020;31:2337-2344.	Retrospective comparison of TBS to BMD – blinded review of registry population	Women in Manitoba aged ≥ 50 years who had a baseline DXA scan and for whom spine and hip DXA data, L1-4 TBS, and fracture data were available, with BMI between 15 & 37; with prior (n = 4649) or incident (n = 2547) fracture	Osteoporosis	Including TBS with BMD increases identification of abnormal bone in women with fracture compared with BMD alone. Normal bone is present in < 6% of women (by BMD) decreased to 4% by adding TBS to BMD with any fracture and < 1% of those with hip fracture.
G. Gutierrez-Buey, P. Restituto, S. Botella, I. Monreal, I. Colina, M. Rodriquez-Fraile, A Calleja, N. Varo. Trabecular bone score and bone remodelling markers identify perimenopausal women at high risk of bone loss. *Clin Endocrinol (Oxf).* 2019;91:391–399.	Prospective cohort study	N = 64 Caucasian women (mean age 49.3 ± 2.6 years) whose menstruation cycles were consistently regular and who were in the age of the transmenopause onset	Osteopenia and osteoporosis	The finding of a moderate correlation between BMD and TBS suggests that these techniques measure different characteristics of the bone and could be used complementarily in the clinical practice. This idea is reinforced by the finding that all women at enrolment had normal bone according to BMD but 10.9% had TBS lower than 1.3. The finding that all women with deteriorated microarchitecture at baseline (low TBS) had higher percentage of bone loss and osteopenia or osteoporosis at follow-up suggests that TBS could be a useful tool to detect women at high risk of developing osteoporosis.
E.S. Leib, R. Winzenrieth. Bone status in glucocorticoid-treated men and women. *Osteoporos Int*. 2016;27: 39-48.	Retrospective cohort study	N = 416 glucocorticoid-treated non-Hispanic white US women and men from a densitometer database from a single institution. aged 40 years and older, BMI lower than 35, with or without fracture N = 1104 controls.	Osteoporosis	GC-treated individuals have a significant deterioration of bone microarchitectural texture as assessed by TBS which is more marked in those with OPF and in men. TBS seems to be more sensitive than aBMD for GC-related fracture detection and should be a good surrogate indicator of bone health in such secondary osteoporosis.

Clinical Evidence Overview

Prepared by ADVI

(Osteoporosis cont.)

Citation	Design	Population	Condition	Outcomes
N.V. Sandeep, A. Joseph, K.E. Cherian, N. Kapoor, T.V. Paul. Impact of Teriparatide Therapy in Indian Postmenopausal Women with Osteoporosis with Regard to DXA-Derived Parameters. *Ther Adv Endocrinol Metab*. 2022;13:1-8	Observational prospective study	51 postmenopausal women >50 years of age in India	Osteoporosis	After 24 months of treatment with cholecalciferol, calcium carbonate and teriparatide, there was a statistically significant improvement in lumbar spine bone mineral density and TBS. Mean TBS increased 9.6% at 2 years of treatment compared to baseline indicating that TBS can be used to identify improvement in bone health.

Treatment

Citation	Design	Population	Condition	Outcomes
M. McClung, E. Shevroja, et al. Updated Trabecular Bone Score accounting for the soft tissue thickness (TBSTT) demonstrated significantly improved bone microstructure with denosumab in the FREEDOM TBS post-hoc analysis. *Osteoporosis International* 2022; accepted for publication	Observational prospective study		Osteoporosis	After treatment with denosumab, there was a statistically significant improvement in TBS demonstrating a significant improvement in microstructure, indicating that TBS can be used to identify improvement in bone health and monitor patients on denosumab.

Clinical Evidence Overview (Diabetes)

Prepared by ADVI

Citation	Design	Population	Condition	Outcomes
V. V. Zhukouskaya, C. Ellen-Vainicher, A. Gaudio, F. Privitera, E. Cairoli, F. M. Ulivieri, S. Palmieri, V. Morelli, V. Grancini, E. Orsi, B. Masserini, A. M. Spada, C. E. Fiore, I. Chiodini. The utility of lumbar spine trabecular bone score and femoral neck bone mineral density for identifying asymptomatic vertebral fractures in well-compensated type 2 diabetic patients. *Osteoporos Int*. 2016. 27:49-56.	Prospective RCT	N = 99 postmenopausal women with T2D in good metabolic control (glycosylated haemoglobin 6.8±0.7 %) N = 107 control subjects without T2D	Vertebral fracture in patients with T2D	The combination of TBS ≤1.130 and FN-BMD less than −1.0 had the best diagnostic accuracy for detecting T2D fractured. TBS and FN-BMD below certain cutoffs may be useful for identifying VFx in well-compensated T2D patients.
W. D. Leslie, B. Aubry-Rozier, O. Lamy, Da. Hans. TBS (Trabecular Bone Score) and Diabetes-Related Fracture Risk. *J Clin Endocrinol Metab*. 2013. 98(2):602-609.	Retrospective cohort study	Manitoba Registry N = 29,407 women ≥50 years or older (2,356 with diabetes)	Osteoporotic fracture in patients with diabetes	TBS correlates with, but does not have the resolution to directly measure, bone microarchitecture. The contribution of the vertebral body trabecular network to the gray levels in a DXA image is difficult to determine relative to the contributions of bone geometry, soft tissue composition, detector heterogeneity, and image noise. Despite these uncertainties, clinical results obtained in large populations show that spine TBS predicts fragility fractures independent of BMD. The current study suggests that spine TBS may be particularly helpful in type 2 diabetes in which BMD is paradoxically increased. Lumbar spine TBS is sensitive to skeletal deterioration in postmenopausal women with diabetes, whereas BMD is paradoxically greater. Lumbar spine TBS predicts osteoporotic fractures in those with diabetes and captures a larger portion of the diabetes-associated fracture risk than BMD. Combining lumbar spine TBS with BMD incrementally improves fracture prediction.

Clinical Evidence Overview (Diabetes)

Prepared by ADVI

Citation	Design	Population	Condition	Outcomes
V. V. Zhukouskaya, C. Ellen-Vainicher, A. Gaudio, F. Privitera, E. Cairoli, F. M. Ulivieri, S. Palmieri, V. Morelli, V. Grancini, E. Orsi, B. Masserini, A. M. Spada, C. E. Fiore, I. Chiodini. The utility of lumbar spine trabecular bone score and femoral neck bone mineral density for identifying asymptomatic vertebral fractures in well-compensated type 2 diabetic patients. *Osteoporos Int*. 2016. 27:49-56.	Prospective RCT	N = 99 postmenopausal women with T2D in good metabolic control (glycosylated haemoglobin 6.8±0.7 %) N = 107 control subjects without T2D	Vertebral fracture in patients with T2D	The combination of TBS ≤1.130 and FN-BMD less than −1.0 had the best diagnostic accuracy for detecting T2D fractured. TBS and FN-BMD below certain cutoffs may be useful for identifying VFx in well-compensated T2D patients.
W. D. Leslie, B. Aubry-Rozier, O. Lamy, Da. Hans. TBS (Trabecular Bone Score) and Diabetes-Related Fracture Risk. *J Clin Endocrinol Metab*. 2013. 98(2):602-609.	Retrospective cohort study	Manitoba Registry N = 29,407 women ≥50 years or older (2,356 with diabetes)	Osteoporotic fracture in patients with diabetes	TBS correlates with, but does not have the resolution to directly measure, bone microarchitecture. The contribution of the vertebral body trabecular network to the gray levels in a DXA image is difficult to determine relative to the contributions of bone geometry, soft tissue composition, detector heterogeneity, and image noise. Despite these uncertainties, clinical results obtained in large populations show that spine TBS predicts fragility fractures independent of BMD. The current study suggests that spine TBS may be particularly helpful in type 2 diabetes in which BMD is paradoxically increased. Lumbar spine TBS is sensitive to skeletal deterioration in postmenopausal women with diabetes, whereas BMD is paradoxically greater. Lumbar spine TBS predicts osteoporotic fractures in those with diabetes and captures a larger portion of the diabetes-associated fracture risk than BMD. Combining lumbar spine TBS with BMD incrementally improves fracture prediction.

Vignettes Of Typical Patients

Prepared by ADVI

A 69-year-old female, who had a previous bone-density study, presents with demonstrated osteopenia.

A 54-year-old female, who is postmenopausal, presents with current tobacco use, a family history of osteoporosis, and a Type II diabetes.

A 55-year-old female with 20-year history of rheumatoid arthritis is receiving treatment with methotrexate and tocilizumab. In 2017, her BMD spine L1-L4 T-score was -1.35 and her 10-year probability of major osteoporotic fracture was 11% when using FRAX. In 2020, her FRAX values for major osteoporotic fracture increased to 18%. Her clinician requested postprocessing analysis by TBS for her last three DXA visits.

A 60-year-old male, who has a history of corticosteroids use, presents with bilateral knee osteoarthritis.

A 47-year-old female presents with a history of breast cancer treated with anti-aromatase inhibitors.

A 45 year old male athletes who is scheduled to have a knee replacement.

CPT Coding – Released by CMS January 1, 2022

Prepared by ADVI

CPT Code	Description
77089	Trabecular bone score (TBS), structural condition of the bone microarchitecture; using dual X-ray absorptiometry (DXA) or other imaging data on gray-scale variogram, calculation, with interpretation and report on fracture-risk
77090	Trabecular bone score (TBS), structural condition of the bone microarchitecture; technical preparation and transmission of data for analysis to be performed elsewhere
77091	Trabecular bone score (TBS), structural condition of the bone microarchitecture; technical calculation only
77092	Trabecular bone score (TBS), structural condition of the bone microarchitecture; interpretation and report on fracture-risk only by other qualified health care professional

There are 4 unique codes. 77089 describes the complete TBS service when the TBS software is installed on the imaging equipment, including physician review and interpretation of the TBS report. 77090 is used to report when data is extracted from the imaging equipment and sent elsewhere for TBS analysis. 77091 is for when only the TBS calculation is performed and 77092 captures the physician review and interpretation of TBS. 77090 and 77091 are technical work only.

2022 Medicare Physician Payment

CPT Code	Description	Work RVU	Non-facility PE RVU	Facility PE RVU	PLI RVU	National Non-facility Payment	National Facility Payment
77089	Trabecular bone score (TBS), structural condition of the bone microarchitecture; using dual X-ray absorptiometry (DXA) or other imaging data on gray-scale variogram, calculation, with interpretation and report on fracture-risk	0.20	0.97	NA	0.03	$41.53	NA
77090	Trabecular bone score (TBS), structural condition of the bone microarchitecture; technical preparation and transmission of data for analysis to be performed elsewhere	0.00	0.06	NA	0.01	$2.42	NA
77091	Trabecular bone score (TBS), structural condition of the bone microarchitecture; technical calculation only	0.00	0.82	NA	0.01	$28.72	NA
77092	Trabecular bone score (TBS), structural condition of the bone microarchitecture; interpretation and report on fracture-risk only by other qualified health care professional	0.20	0.09	0.90	0.01	$10.38	$10.38

2022 Medicare Hospital Outpatient Payment

CPT Code	Description	APC	Relative Weight	Payment Rate
77089	Trabecular bone score (TBS), structural condition of the bone microarchitecture; using dual X-ray absorptiometry (DXA) or other imaging data on gray-scale variogram, calculation, with interpretation and report on fracture-risk	NA	NA	NA
77090	Trabecular bone score (TBS), structural condition of the bone microarchitecture; technical preparation and transmission of data for analysis to be performed elsewhere	5521	0.9814	$82.61
77091	Trabecular bone score (TBS), structural condition of the bone microarchitecture; technical calculation only	5521	0.9814	$82.61
77092	Trabecular bone score (TBS), structural condition of the bone microarchitecture; interpretation and report on fracture-risk only by other qualified health care professional	NA	NA	NA

Note: Medicare does not pay for physician services on the OPPS

For more information, please visit our website www.medimapsgroup.com