DEXA measurements, bone mineral density, and trabecular bone score in patients with lumbar spondylosis in Basrah , Iraq

By

Samih Naeem Jabbar[*1] ; Dr. Husham A. Aldaoseri [2] ; Mubder A. Mohammed Saeed[*3]

[*1] M.B.Ch.B., D.O.S., diploma in orthopedic surgery, University of Basrah, College of Medicine, Al-Diwaneya teaching hospital/ [*2] MB ChB. DRMR.phD CI, Medicine department, Rheumatology division, Faculty of Medicine, University of Basrah, Basrah, Iraq /[*3] MBChB. FICMS Orthopaedic FRCS Glasgow.Consultant Orthopaedic Surgeon , University of Basrah, College of Medicine.

Abstract:

Background: Degenerative diseases associated with aging lumbar spondylosis, a higher lumbar spine BMD (bone mineral density) may be artifactually caused by osteophytes. TBS (trabecular bone score) is a textural metric that uses specialized software to assess pixel grey level changes in lumbar spine DEXA (dual-energy x-ray absorptiometry) images can used alternative measure the risk of fracture.The purpose of the research was to compare the TBS and BMD scores in patients with lumbar spondylosis and the contribution of TBS, BMD, measurements from DEXA to the prediction of fracture risk.**Patients and Method:** In this cross-sectional comparative research, 250 participants with and without sciatica had back discomfort. Every patient answered questions on osteoporosis risk factors and sociodemographic characteristics. A conventional radiography was used, with the film centred at the second lumbar vertebra. A lone observer then assessed the radiographs to determine if the patient had lumbar spondylosis using the Kellgren-Lawrence Score. The patients were split into two groups: those with spondylosis in group B and those without (group A). The GE-Lunar Prodigy Advance instrument and program (encore version 17) were used to measure the bone mineral density (BMD) of the lumbar spine (first to fourth lumbar vertebrae). Anteroposterior DEXA was reanalyzed as part of the TBS evaluation risk in patients with lumbar spondylosis. **Results:** Lower TBS (only 31.3% of grade 1 spondylosis cases had a TBS < 1.20, while 73.7% of grade 4 spondylosis cases had a TBS < 1.20 with a p value of 0.044) and increased BMD (50% of grade 1 spondylosis cases had a BMD <-2.5, compared to only 5.3% of grade 4 spondylosis cases had a BMD <-2.5 with a p value of 0.018) were found to be associated with lumbar spondylosis. Additionally, BMD is not significantly correlated with TBS in cases with spondylosis (TBS <1.20 with p value of 0.391 in 37.5% of cases with BMD >-1 and 44.4% of patients with BMD <-2.5 had TBS > 1.20). This is in contrast to findings in instances without spondylosis (54.0% of cases with BMD <-2.5 had TBS > 1.20 and, with a p-value of 0.001, 32.7% of cases with BMD >-1 had TBS <1.20. The correlation coefficients in groups A and B for BMD and FRAX were -0.820 and -0.708, respectively, indicating a weaker relationship between the two variables in the spondylosis cases compared to the non-spondylosis cases. However, there was no significant difference in the correlation coefficients for TBS and FRAX between the spondylosis and non-spondylosis cases (-0.373 and -0.436, respectively, with a p value of 0.486).**Conclusion:** The lumbar spine's TBS provides a more precise indicator of the likelihood of a

fracture in cases of lumbar spondylosis. Lumbar spondylosis's radiographic characteristics raised BMD but had no effect on TBS values.

Keywords: DEXA, BMD, TBS, osteoporosis, lumber spondylosis

Introduction

Osteoporosis and osteoarthritis are age-related degenerative conditions. Several investigators have examined the coexistence of osteoporosis and spondylosis in the spine, and have reported an inverse relation between decreased bone mineral density (BMD) and intervertebral disc degeneration. In subjects with osteophyte formation or facet joint osteoarthritis, BMD is known to be higher than in normal controls. In these subjects, increased BMD is observed not only in the lumbar spine, but also throughout the skeleton.[1]

In contrast, several conflicting results have been reported regarding the correlation between bone mass density and spondylosis. [2]

Dual Energy X-Ray Absorptiometry (DXA) scans are able to assess Bone Mineral Density (BMD) [3]. A reduction in bone mass and degradation of skeletal architecture is typical of osteoporosis. Immediate appraisal of the skeletal microarchitecture could therefore improve the accuracy of measurement of bone strength parameters and fracture risk [4].

TBS serves as a textual indicator, assessing variations in gray-level pixels within lumbar spine DEXA images to indirectly gauge trabecular microarchitecture. [5].

Patients and Methods

This cross-sectional comparative study involved patients who suffer from back pain with or without sciatica. The patients were seen in Basrah Teaching Hospital from April 1st 2022 to July 1st 2023.

Recruitment was based on voluntary enrolment. Written informed consent was obtained from all subjects and the study was approved by the Ethical Committee of University of Basrah, College of Medicine. 030409-072-2022.

We excluded from the study all patients with a history of:

(1) Taking medications known to influence bone metabolism in the past two years, such as vitamin D, calcium, corticosteroids, bisphosphonates, sodium fluoride, raloxifene, strontium ranelate, teriparatide and antiepileptic drugs

(2) Musculoskeletal disease, thyroid disease, parathyroid disease, adrenal disease, hepatic disease, renal disease, or diabetes mellitus.

(3) Previous spine fracture or surgery.

Each patient completed a questionnaire on socio-demographic parameters and osteoporosis risk factors such as sex, age, family history of osteoporosis, BMI, smoking, sedentary lifestyle, long term (≥3 months) corticosteroid use and alcohol consumption. Weight and height were measured without shoes at the time of bone densitometry measurements. The body mass index (BMI) was calculated as body weight divided by height squared (Kg/m^2).

Lumbar spine radiographs were taken according to a standard protocol with the film centred at L2. The radiographs were subsequently evaluated by a single observer for the presence of the individual radiographic features of lumbar spondylosis. Each vertebral level from L1/2 to L4/5 was assessed for the presence and severity of osteophytes, subchondral sclerosis, and DSN according to Kellgren–Lawrence Score. (Table 3.1) [6]

The sample was divided to two groups; group A without lumbar spondylosis and group B with lumbar spondylosis.

The bone mineral density (BMD) of the lumbar spine (L1-L4) was assessed by employing the GE-Lunar Prodigy Advance device along with its corresponding software (encore version 17), reference population: USA. Two devices of identical type and model were utilized, and the examination was carried out by two proficient operators. Both the lateral and anteroposterior projections were used to scan the vertebral bodies, including their posterior arches, utilizing the array and single-beam modes respectively. The scanner software's default mode was employed to calculate density. Following the guidelines of the World Health Organization (WHO) classification criteria, osteoporosis was identified for T-scores≤-2.5 standard deviations (SD) from the mean BMD at the lumbar spine. Osteopenia was characterized by T-scores between -1 SD and -2.5 SD, while T-scores greater than -1 SD were considered indicative of normal bone density. [7]

TBS assessment involved a reanalysis of anteroposterior DEXA LS (L1-L4) scans using TBS iNsight software version 3.0.3.0. The same regions used for BMD measurement were employed for evaluating TBS. The TBS value was derived as the average of individual measurements across each vertebra (L1-L4) as well as their combinations. Patients were classified into three groups based on their TBS scores: the normal micro-architecture (NM) group (TBS ≥ 1.35), the partially degraded micro-architecture (PDM) group (1.2 < TBS < 1.35), and the fully degraded micro-architecture (FDM) group (TBS < 1.20).[8]

TBS weighted FRAX were calculated using the online FRAX assessment tool provided by University of Sheffield.[9]

Variable distribution difference was tested by chi square for sex and by Levene's test for age and BMI. Age was categorized into three categories (below 45years, 45-60 years, and above 60 years). The weight into 4 categories (underweight, normal, overweight, and obese) according to CDC classification [10], Cross tabulation with chi square and Fisher's exact tests were used to calculate the significance of the relation between categorical variables. Pearson and Fisher's z-test were used to test the relationship of BMD and TBS weighted FRAX and the significance of their difference between group A and group B. P values obtained p value lower than 0.05 were considered as statistically significant. Statistical analysis was performed with SPSS for Windows 26.

Results

The distribution of variables between group A and Group B is shown in table (1). there is no significant difference in the distribution of sex, age and BMI between group A and B since the p values were 0.295, 0.062, and 0.519 for them respectively.

The main finding in our study were: a) There was increase in BMD and decrease in TBS as the OA get more advanced (table5), b) There was a significant association between BMD and TBS in cases without spondylosis while there was no significant association between BMD and TBS in cases with spondylosis (table 4), c) There was difference in the relationships of BMD with age, sex, and BMI between the two groups (A and B) (table 2) but no difference in the relationships of TBS with age, sex, and BMI between the two groups (A and B) (table 3) , d) The relation of BMD with FRAX is significantly different between those with and without spondylosis, while TBS relation with FRAX did not show significant difference between the two groups (A and B) (table 6).

Table 1: The distribution of variables between group A and Group B

Variable	Group A	Group B	P value
Sex (male% / female)	24.7% / 75.3%	18.8% / 81.2%	0.295
Age Mean ± SD	56.33 ± 9.447	57.78 ± 10.495	0.062
BMI Mean ± SD	27.076 ± 5.1053	26.845 ± 5.2533	0.519

Table 2: The association of sex, age, and BMI with BMD

Group	**Variable**		**BMD**						**P value**
			Normal		**Osteopenia**		**Osteoporosis**		
			Count	Row N %	Count	Row N %	Count	Row N %	
Group A	**Sex**	female	35	27.3 %	49	38.3 %	44	34.4 %	.015*
		male	20	47.6 %	16	38.1 %	6	14.3 %	
	Age Category	Below 45 yrs	5	62.5 %	2	25.0 %	1	12.5 %	.001**
		45-60 yrs	41	34.5 %	52	43.7 %	26	21.8 %	
		Above 60 yrs	9	20.9 %	11	25.6 %	23	53.5 %	
	BMI Category	Obese	15	27.3 %	25	45.5 %	15	27.3 %	.013*
		Overweight	27	42.2 %	20	31.3 %	17	26.6 %	
		Normal	13	37.1 %	14	40.0 %	8	22.9 %	
		Underweight	0	0.0%	6	37.5 %	10	62.5 %	
Group B	**Sex**	female	34	52.3 %	17	26.2 %	14	21.5 %	.654
		male	6	40.0 %	5	33.3 %	4	26.7 %	
		Below 45 yrs	2	40.0 %	1	20.0 %	2	40.0 %	.742

	Age Category	45-60 yrs	26	55.3 %	12	25.5 %	9	19.1 %	
		Above 60 yrs	12	42.9 %	9	32.1 %	7	25.0 %	
	BMI Category	Obese	16	59.3 %	8	29.6 %	3	11.1 %	.473
		Overweight	12	46.2 %	8	30.8 %	6	23.1 %	
		Normal	10	45.5 %	4	18.2 %	8	36.4 %	
		Underweight	2	40.0 %	2	40.0 %	1	20.0 %	
*. The Chi-square statistic is significant at the .05 level.									
**. Fisher Exact test is significant at the .05 level.									

Table 3: The association of sex, age, and BMI with TBS

Group	**Variable**		**TBS**						**P value**
			Normal		**Partially Degraded**		**Degraded**		
			Count	Row N %	Count	Row N %	Count	Row N %	
Group A	**Sex**	female	24	18.8 %	47	36.7 %	57	44.5 %	.011*
		male	17	40.5 %	14	33.3 %	11	26.2 %	
	Age Category	Below 45 yrs	6	75.0 %	2	25.0 %	0	0.0%	.022*
		45-60 yrs	28	23.5 %	43	36.1 %	48	40.3 %	
		Above 60 yrs	8	18.6 %	16	37.2 %	19	44.2 %	
	BMI Category	Obese	13	23.6 %	19	34.5 %	23	41.8 %	.152
		Overweight	20	31.3 %	22	34.4 %	22	34.4 %	
		Normal	7	20.0 %	16	45.7 %	12	34.3 %	
		Underweight	1	6.3%	4	25.0 %	11	68.8 %	

Group B	**Sex**	female	13	20.0 %	22	33.8 %	30	46.2 %	.015 *
		male	8	53.3 %	5	33.3 %	2	13.3 %	
	Age Category	Below 45 yrs	3	60.0 %	1	20.0 %	1	20.0 %	.034 **
		45-60 yrs	14	29.8 %	19	40.4 %	14	29.8 %	
		Above 60 yrs	4	14.3 %	7	25.0 %	17	60.7 %	
	BMI Category	Obese	8	29.6 %	11	40.7 %	8	29.6 %	.372
		Overweight	5	19.2 %	10	38.5 %	11	42.3 %	
		Normal	5	22.7 %	6	27.3 %	11	50.0 %	
		Underweight	3	60.0 %	0	0.0 %	2	40.0 %	
*. The Chi-square statistic is significant at the .05 level.									
**. Fisher Exact test is significant at the .05 level.									

Table 4: The association of BMD with TBS

			TBS						**P value**
			Normal		**Partially Degraded**		**Degraded**		
			Count	Row N %	Count	Row N %	Count	Row N %	
BMD	**Group A**	Normal	23	41.8%	14	25.5%	18	32.7%	.001*
		Osteopenia	11	16.9%	31	47.7%	23	35.4%	
		Osteoporosis	7	14.0%	16	32.0%	27	54.0%	
	Group B	Normal	14	35.0 %	11	27.5 %	15	37.5 %	.391
		Osteopenia	5	22.7 %	8	36.4 %	9	40.9 %	
		Osteoporosis	2	11.1 %	8	44.4 %	8	44.4 %	
*. The Chi-square statistic is significant at the .05 level.									

Table 5: The association of BMD and TBS with spondylosis

		Spondylosis Grade								P value
		Grade1		Grade2		Grade3		Grade4		
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
BMD	Normal	3	7.5 %	11	27.5 %	13	32.5 %	13	32.5 %	.018*
	Osteopenia	5	22.7 %	6	27.3 %	6	27.3 %	5	22.7 %	
	Osteoporosis	8	44.4 %	7	38.9 %	2	11.1 %	1	5.6 %	
TBS	Normal	5	23.8 %	9	42.9 %	5	23.8 %	2	9.5 %	.044**
	Partially Degraded	6	22.2 %	9	33.3 %	9	33.3 %	3	11.1 %	
	Degraded	5	15.6 %	6	18.8 %	7	21.9 %	14	43.8 %	
*. The Fisher's Exact test is significant at the .05 level.										
**. The Chi-square statistic is significant at the .05 level.										

Table 6: Comparison of correlation of BMD and TBS with FRAX between Group A and B

	Correlation Coefficients		P value
	Group A	Group B	
BMD	-.820	-.708	0.03*
TBS	-.373	-.436	0.486
*The Fisher's z-test is significant at the .05 level.			

Discussion

With regard to the relationship of BMD and TBS, in group A (cases without spondylosis), the decreased TBS was associated by decreased BMD and this is expected as osteoporosis, observed as a clinical condition, is distinguished by an unusually diminished bone mass and irregularities in bone composition. [11] which are reflected by BMD and TBS respectively. While in group B (cases with spondylosis), the BMD is not significantly associated with TBS, this may be caused by osteoarthritis impacts bone mineral density (BMD) measurements. Osteoarthritic spondylosis most commonly explains artefactual elevations in calcium content due to abnormally dense bone at the vertebral margins forming vertebral end-plate sclerosis, facet joint sclerosis and osteophytes. Facet joint OA

is particularly marked in the lower lumbar spine, giving the recognized pattern of progressive osteoarthritic changes seen in sequential descending lumbar vertebrae, which correlates with rising BMD measures caudally down the spine. Even mild osteophytosis can result in a 24% increase in lumbar BMD. [12] Furthermore, Patients with osteoarthritis (OA) have shown higher levels of insulin-like growth factors which promotes the development of osteophytes. [13] While the TBS value remains unaffected by the osteoarthritis [14].

A study by S R Pye [15] and et al. found that radiographic characteristics of lumbar spondylosis are linked to elevated bone mineral density (BMD) in the spinal region. In a study by T Masud [16] and et al, they determined that even mild osteophytosis in postmenopausal women with fractures can result in inaccurately elevated measurements of lumbar spine bone mineral density. In another study by G Jones [17] and et al., they concluded that measurement of spinal bone density and its subsequent tracking could be inaccurate among the elderly due to accompanying degenerative conditions. In a study by G Liu [18] and et al., they concluded that osteoarthritis leads to an elevation in the Bone Mineral Density (BMD) of the lumbar spine, as assessed through (DEXA) scans. In study by Husham A. Aldaoseri [19], he concluded that in cohort of degenerative lumbar spine spondylosis patients, an increased incidence of osteoporosis and a degraded skeletal microarchitecture were noted within the lumbar spine. TBS is a standalone, reliable and strong indicator of fracture risk, unrelated to FRAX.

While Naciye Sinem Gezer and et al. [20] showed that individuals with spondylolysis exhibited notably reduced average vertebral body bone mineral density in comparison to the control group. And Astrid Ellen Grams and et al. [21] showed a potential link between degenerative alterations in the spine and a decrease in localized spinal mineralization.

Limitations of the study: There is no TBS normal value standard in our region.

The prevalence of osteoporosis is unknown in our region.

Conflict of interest: There is no conflict of interest and we did not receive financial support from people or organizations.

Ethical approval: Recruitment was based on voluntary enrolment. Written informed consent was obtained from all subjects and the study was approved by

the Ethical Committee of University of Basrah, College of Medicine. 030409-072-2022.

Acknowledgement: We would like to thank all the doctors, nurses and technicians in orthopedic department in Basrah teaching hospital for their cooperation. We would like to thank DEXA scan unit in Basrah teaching hospital and in Al-Zahraa' clinic for their cooperation. Special thanks to the patients involved in the study for their cooperation.

References

1) Miyakoshi N, Itoi E, Murai H, et al. Inverse relation between osteoporosis and spondylosis in postmenopausal women as evaluated by bone mineral density and semiquantitative scoring of spinal degeneration. Spine. 2003 Mar 1;28(5):492-5.
2) Sambrook P, Naganathan V. 4 What is the relationship between osteoarthritis and osteoporosis?. Baillière's clinical rheumatology. 1997 Nov 1;11(4):695-710.
3) JA. Kanis, F. Borgstrom, C. De La et al. Assessment of fracture risk. Osteoporos. Int. 16, 581–589(2005).
4) Majumdar S. A review of magnetic resonance (MR) imaging of trabecular bone micro-architecture: contribution to the prediction of biomechanical properties and fracture prevalence. Technol. Health. Care. 6(5e6), 321e327 (1998)
5) Silva BC, Leslie WD, Resch H, et al. Trabecular bone score: a noninvasive analytical method based upon the DXA image. Journal of Bone and Mineral Research. 2014 Mar;29(3):518-30.
6) Tsujimoto R, Abe Y, Arima K, et al. Prevalence of lumbar spondylosis and its association with low back pain among community-dwelling Japanese women. BMC musculoskeletal disorders. 2016 Dec;17:1-6.
7) Cranney A, Jamal SA, Tsang JF, et al. Low bone mineral density and fracture burden in postmenopausal women. Cmaj. 2007 Sep 11;177(6):575-80.
8) Rajan R, Cherian KE, Kapoor N, Paul TV. Trabecular Bone Score-An Emerging Tool in the Management of Osteoporosis. Indian J Endocrinol Metab. 2020 May-Jun;24(3):237-243. doi: 10.4103/ijem.IJEM_147_20. Epub 2020 Jun 30. PMID: 33083262; PMCID: PMC7539023.
9) University of Sheffield. Fracture Risk Assessment Tool. [Internet]; 2010; cited 2023 July 3. Available from: https://frax.shef.ac.uk/FRAX/index.aspx
10) CDC. Defining Adult Overweight &Obesity. [Internet] Last Reviewed: June 3, 2022; cited 2023 July 28. Available from: https://www.cdc.gov/obesity/basics/adult-defining.html

11) Whitehouse MR. Apley and Solomon's System of Orthopaedics and Trauma. 10th edition. New York: CRC Press. 2017. P 136, 137, 140, 134, 135
12) Gregson CL, Hardcastle SA, Cooper C, et al. Friend or foe: high bone mineral density on routine bone density scanning, a review of causes and management. Rheumatology. 2013 Jun 1;52(6):968-85.
13) Burger H, van Daele PL, Odding E, et al. Association of radiographically evident osteoarthritis with higher bone mineral density and increased bone loss with age. The Rotterdam Study. Arthritis & Rheumatism: Official Journal of the American College of Rheumatology. 1996 Jan;39(1):81-6.
14) Kolta S, Briot K, Fechtenbaum J, et al. TBS result is not affected by lumbar spine osteoarthritis. Osteoporosis International. 2014 Jun;25:1759-64.
15) Pye SR, Reid DM, Adams JE, et al. Radiographic features of lumbar disc degeneration and bone mineral density in men and women. Annals of the rheumatic diseases. 2006 Feb 1;65(2):234-8.
16) Masud T, Langley S, Wiltshire P, et al. Effect of spinal osteophytosis on bone mineral density measurements in vertebral osteoporosis. BMJ: British Medical Journal. 1993 Jul 7;307(6897):172.
17) Jones G, Nguyen TU, Sambrook PN, et al. A longitudinal study of the effect of spinal degenerative disease on bone density in the elderly. The Journal of rheumatology. 1995 May 1;22(5):932-6.
18) Liu G, Peacock M, Eilam O, *et al.* Effect of osteoarthritis in the lumbar spine and hip on bone mineral density and diagnosis of osteoporosis in elderly men and women. Osteoporosis International. 1997 ;7:564-9.
19) Aldaoseri HA. The role of trabecular bone score, in addition to FRAX, for the measurement of fracture risk in patients with degenerative lumbar spine stenosis. Int. J. Clin. Rheumatol. 2021;16(5):172-8.
20) Gezer NS. Balci a., Kalemci o., Köremezli N., et al. Vertebral body bone mineral density in patients with lumbar spondylolysis: a guantitative cT study. Diagn Interv Radiol. 2017;23(5):385-9.
21) Grams AE, Rehwald R, Bartsch A, et al. Correlation between degenerative spine disease and bone marrow density: a retrospective investigation. BMC Medical Imaging. 2016 ;16(1):1-6.