

# The added value of trabecular bone score over bone mineral density for identification of the bone architecture in patients with Inflammatory Bowel Disease

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## Research Article

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# Abstract

## Background and aims:

Patients with Inflammatory Bowel Disease (IBD) suffer from different level of bone diseases in density and architectures. This study has been designed to measure Bone Mineral Density (BMD) and Trabecular Bone Score (TBS) in IBD patients, Golestan province, northeast of Iran.

## Materials and methods:

In this cross-sectional study during January 2018 to August 2018, 69 patients with IBD (UC=57 and Crohn's disease=10; male: female 0.74; mean age, 39 years) recruited from the IBD registry in Golestan Research Center of Gastroenterology and Hepatology. After taking the informed consent, all patients have been interviewed by a trained physician and a questionnaire has been completed. Trabecular bone score (TBS) was performed using lumbar spine dual X-ray absorptiometry (DXA) images. After entering data into the SPSS-16 software, analysis was done using X2 and non-parametric tests.

## Results:

Normal BMD (T Score>-1) was reported in 19 patients, low bone mass (-1 <T Score< -2.5) in 18 and osteoporosis (T Score <-2.5) in 4 patients. TBS results showed that 5 patients had partially degraded microarchitecture and 5 had fully degraded microarchitecture.

## Conclusion:

In the present study on IBD patients, age, BMI, waist circumference and abdominal circumference had been correlated significantly with bone weakness. The duration of disease was correlated significantly with FRAX. The duration of disease was also correlated significantly with risk of major osteoporotic fracture in 10-years (FRAX adjusted MOF).

## Introduction

Inflammatory bowel diseases (IBDs) are the chronic inflammatory diseases of the gastrointestinal tract which consists of Crohn's disease (CD) and ulcerative colitis (UC) (1). Many patients have extraintestinal symptoms in addition to intestinal complaints (2-4). Extraintestinal manifestations most commonly affect the joints, skin and eyes, and some other organs. There are two kinds of extraintestinal complications, some are caused by the disease itself and some are caused by treatments (3, 5).

Previous studies have shown decreased bone mineral density in patients with IBD (6-8). Calcium malabsorption, altered sex hormonal status, malnutrition and vitamin D deficiency are possible factors for osteoporosis associated with IBD (7, 9). Bone density measurement with Dual Energy X-ray Absorptiometry (DXA) is currently the best means of detecting osteoporosis. This method can measure the amount of bone minerals which is an important factor in bone strength. But there is remarkable

overlap in BMD values between individuals who develop fractures and those who do not (10, 11). There are other factors involved in bone strength and fracture risk such as macro geometry of cortical bone, the microarchitecture of trabecular bone, bone microdamage, mineralization, and turnover (12, 13).

The trabecular bone score (TBS) is a new texture measurement that can be applied to any X-ray images. Significant correlations have been identified between TBS and 3D parameters of bone microarchitecture, independent of any correlation between TBS and BMD (14, 15). Also, TBS could predict fractures almost as well as BMD but the combination was reported superior to either measurement alone (10, 15). The aim of the study was to evaluate the added value of TBS over BMD for identification of the bone architecture in patients with inflammatory bowel disease.

## Materials And Methods

### Study population

The study population included patients with biopsy-proven inflammatory bowel disease (IBD) registered in the Golestan Research Center of Gastroenterology and Hepatology (GRCGH) in Gorgan, Northeast of Iran; during January 2018 to August 2018. All registered patients with IBD (N=100) have been invited through phone calls to participate in the study. The exclusion criteria included cases with severe disease activity, hospital admission at the time of study and during the last month, history of trauma after the diagnosis of IBD, pregnant women and not willing to have an x-ray or children younger than 18 years.

Patient's demographic information (age, sex, ethnicity), colonoscopy and biopsy results from patient records, as well as information on vitamin D and calcium supplements and menopause of female patients were recorded.

### Imaging

All patients were referred to the imaging center for evaluation of bone mineral density (BMD) and trabecular bone score (TBS). The device Hologic Horizon WI Bone Densitometer was used in the center. BMD was measured in the lumbar spine and femoral neck using DXA method. In accordance with international standards, T-score less than one standard deviation (SD) compared to maximal adult test was considered as bone mass reduction and less than 2.5 standard deviation as osteoporosis.

Bone density was measured in the lumbar spine (L2-L4) and proximal femur (femoral neck, trochanter and Ward) using a dual-energy X-ray absorptiometry (Lunar).

TBS (absolute value) was obtained after re-analyzing DXA images from lumbar spine scan using TBS software and Horizon device. TBS was calculated as the mean of individual measurements for L1-L4 vertebrae (table 1).

Fracture Risk Assessment Tool (FRAX) was also calculated based on TBS, to measure the risk of fracture in 10-years in all subjects.

## Statistics

After entering the data in SPSS version 16, the data were analyzed using mean, standard deviation, frequency and percentage. Chi-square test was used to compare the qualitative variables.

## Results

In this cross-sectional study on 69 IBD patients with mean (SD) age of 40.82 (12.18) years, mean (SD) of the disease duration of 6.72 (7.18) years, 39 were female (56.5%). Among them 57 (82.6%) were ulcerative colitis, 10 (14.5%) were Crohn's disease and 2 (2.9%) were undifferentiated colitis (Table 2).

As seen in table 3, comparing the results of BMD and TBS in IBD patients showed some discrepancies between the results, and in some cases (N=3) TBS showed partially degraded bone while BMD showed them normal. On the other hand, 22 has normal report in TBS but low density or osteoporosis in BMD (Table 3).

Sex and IBD type had shown no significant differences in TBS, BMD and FRAX, although females had higher risk of fracture and lower TBS or BMD (Table 4).

Age had a significant correlation with the three measurements, but BMI, waist circumference and abdominal circumference had been correlated significantly with TBS. The duration of disease was also correlated significantly with FRAX (Figure 1).

FRAX-adjusted-MOF was significantly correlated with TBS ( $r=-0.528$ ,  $P<0.001$ ) and BMD results ( $r=-0.411$ ,  $P<0.001$ ). There was also a significant positive correlation between TBS and BMD ( $r=0.414$ ,  $P<0.001$ ).

## Discussion

In the present study, our results indicated stronger correlation between FRAX and TBS than FRAX and BMD, similarly to the previous studies (16), that raises the question whether TBS is a more accurate tool for predicting bone involvement than BMD. It has been shown that FRAX adjusted with TBS has a better predictive role than FRAX alone (16).

Correlation between the spine BMD and TBS was significant in the present study, similar to the previous studies that suggested enhanced gradients of risks when the results of TBS and BMD are combined together compared to the TBS or FRAX alone (17). According to the Hans et al, when BMD levels are close to the intervention threshold, TBS can be more useful in predicting the risk of future fracture risk (4). Similarly, our results showed that according to the BMD results, six patients considered to have osteoporosis, while TBS results showed that two of them does not need any intervention and classified as the normal group.

Our results suggested that the correlations between TBS and WC, AC, and BMI are stronger than BMD which raises the question whether obesity affects bone microarchitecture more than bone densit. Rates

of obesity are rising in patients with IBD, as in the general population; 15–40% of adults with IBD are obese, and 20–40% are overweight (18, 19). Previous studies showed that the higher adiposity in early life in pediatrics with IBD and also in newly diagnosed IBD patients is significantly associated with reduced bone mass, as shown by BMD z-score (20, 21).

Obesity or fat accumulation affects bone in different ways. The fact that mesenchymal stem cells generates both osteoblasts and adipocytes is the cornerstone of the connections between their metabolisms. Obesity has positive effects on bone formation by decreasing apoptosis and increasing proliferation and differentiation of osteoblasts and osteocytes (22-24).

BMI or bodyweight is also showed a positive correlation with bone mineral density or bone mass. But there are evidences that shows negative consequences of fat accumulation on total bone mineral density and content; for instance, increased adiposity is a risk factor for bone fracture (25-26).

As the source of these two types of the cells is the same, increase adipocytes differentiation may lead to decrease osteoblast differentiation (27). Also, elevation of proinflammatory cytokines such as including TNF- $\alpha$ , IL-1, and IL-6 due to obesity increase bone resorption and bone loss in IBD patients (28).

On the other hand, high-fat diet decreases intestinal absorption of calcium (29). These evidences show that the effects of obesity and its related condition on bone are two sided and yet these interactions are not clearly defined. Considering these facts, obesity effects could have different faces in BMD and TBS.

Introduction of TBS to the routine methods of bone densitometry, showed better prediction of the fraction risk. In a cohort study in Korea (2001-2014) 4000 Chinese men and women aged 65 years old or above were recruited; It showed that the combination of TBS to the BMD could better predict MOF compared to BMD alone, especially in older men (30). On the other hand, Nassar et al (2013, France) reported that TBS and BMD could detect patients with and without vertebral fractures, but when BMD is in the non-osteoporotic range, TBS would add more information to BMD lumbar spine alone and could better show spine deterioration (31).

According to our results, BMD was reduced in both UC and CD patients while some studies demonstrated that the reduction of BMD only appears in CD patients, not in UC patients (2). This conflict can lead us to further investigations.

The major limitation in this cross-sectional study was that we evaluated the density and trabecular bone mass in IBD patients at a time point with no follow up.

## Conclusions

Age, BMI, waist circumference and abdominal circumference had been correlated significantly with bone weakness in IBD patients. The duration of disease was also correlated significantly with risk of major osteoporotic fracture in 10-years (FRAX-adjusted-MOF). So, it should be notified that early diagnosis of

patients with chronic diseases that are at higher risk of fractures would have more economical benefits for the community.

## Declarations

- Ethics approval and consent to participate

The study protocol was carried out in accordance with the Declaration of Helsinki. This research project has been approved in the local ethical committee of the Golestan University of Medical Sciences (IR.GOUMS.REC.1398.155). The research protocol had been explained to all participants and an informed consent has been taken from all.

- Consent for publication

Not applicable

- Availability of data and materials

Not applicable

- Competing interests

Authors declare no conflict of interests.

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- Authors' contributions

S.T. and A.N. contributed in coception and design, acquisition of data, drafting the article and give final approval of the version to be submitted.

Z.E., A.N., and T.A. contributed to the acquisition of data, drafting the article or revising it critically for important intellectual content and give final approval of the version to be submitted.

S.T., and A.S. contributed in analysis and interpretation of data, drafting of manuscript and critical revision of the final draft.

S.B. and F.I.A. contributed substantially in acquisition of data, drafting the manuscript and interpretation of data.

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## References

1. Pithadia AB, Jain S. Treatment of inflammatory bowel disease (IBD). *Pharmacol Rep.* 2011;63(3):629-42.
2. Jahnsen J, Falch J, Aadland E, Mowinckel P. Bone mineral density is reduced in patients with Crohn's disease but not in patients with ulcerative colitis: a population based study. *Gut.* 1997;40(3):313-9.
3. Ott C, Schölmerich J. Extraintestinal manifestations and complications in IBD. *Nat Rev Gastroenterol Hepatol.* 2013;10(10):585.
4. Hans D, Šteňová E, Lamy O. The trabecular bone score (TBS) complements DXA and the FRAX as a fracture risk assessment tool in routine clinical practice. *Curr Osteoporos Rep.* 2017;15(6):521-31.
5. Su CG, Judge TA, Lichtenstein GR. Extraintestinal manifestations of inflammatory bowel disease. *Gastroenterol Clin NorthAm.* 2002;31(1):307-27.
6. Bjarnason I, Macpherson A, Mackintosh C, Buxton-Thomas M, Forgacs I, Moniz C. Reduced bone density in patients with inflammatory bowel disease. *Gut.* 1997;40(2):228-33.
7. Compston J, Judd D, Crawley E, Evans W, Evans C, Church H, et al. Osteoporosis in patients with inflammatory bowel disease. *Gut.* 1987;28(4):410-5.
8. Pigot F, Roux C, Chaussade S, Hardelin D, Pelleter O, Montbrun TDP, et al. Low bone mineral density in patients with inflammatory bowel disease. *Dig Dis Sci.* 1992;37(9):1396-403.
9. Hahn T, Boisseau V, Avioli L. Effect of chronic corticosteroid administration on diaphyseal and metaphyseal bone mass. *J Clin Endocrinol Metab.* 1974;39(2):274-82.
10. Hans D, Goertzen AL, Krieg MA, Leslie WD. Bone microarchitecture assessed by TBS predicts osteoporotic fractures independent of bone density: the Manitoba study. *J Bone Miner Res.* 2011;26(11):2762-9.
11. Hordon L, Raisi M, Aaron J, Paxton S, Beneton M, Kanis J. Trabecular architecture in women and men of similar bone mass with and without vertebral fracture: I. Two-dimensional histology. *Bone.* 2000;27(2):271-6.
12. Link TM, Majumdar S. Current diagnostic techniques in the evaluation of bone architecture. *Curr Osteoporos Rep.* 2004;2(2):47-52.
13. Rubin CD. Emerging concepts in osteoporosis and bone strength. *Current medical research and opinion.* 2005;21(7):1049-56.
14. Hans D, Barthe N, Boutroy S, Pothuau L, Winzenrieth R, Krieg M. Correlations between TBS, measured using antero-posterior DXA acquisition, and 3D parameters of bone micro-architecture: an experimental study on human cadavre vertebrae. *J Clin Densitom.* 2011;14(3):302-11.

15. Pothuaud L, Barthe N, Krieg M-A, Mehse N, Carceller P, Hans D. Evaluation of the potential use of trabecular bone score to complement bone mineral density in the diagnosis of osteoporosis: a preliminary spine bmd-matched, case-control study. *J Clin Densitom.* 2009;12(2):170-6.
16. McCloskey EV, Odén A, Harvey NC, Leslie WD, Hans D, Johansson H, et al. Adjusting fracture probability by trabecular bone score. *Calcif Tissue Int.* 2015;96(6):500-9.
17. Leslie WD, Johansson H, Kanis JA, Lamy O, Oden A, McCloskey EV, et al. Lumbar spine texture enhances 10-year fracture probability assessment. *Osteoporos Int.* 2014;25(9):2271-7.
18. Bryant RV, Schultz CG, Ooi S, Goess C, Costello SP, Vincent AD, et al. Obesity in inflammatory bowel disease: gains in adiposity despite high prevalence of myopenia and osteopenia. *Nutrients.* 2018;10(9):1192.
19. Singh S, Dulai PS, Zarrinpar A, Ramamoorthy S, Sandborn WJ. Obesity in IBD: epidemiology, pathogenesis, disease course and treatment outcomes. *Nat Rev Gastroenterol Hepatol.* 2017;14(2):110.
20. Setty-Shah N, Maranda L, Nwosu BU. Adiposity is associated with early reduction in bone mass in pediatric inflammatory bowel disease. *Nutrition.* 2016;32(7-8):761-6.
21. Lee SH, Kim HJ, Yang SK, Kim WH, Joo YS, Dong SH, et al. Decreased trabecular bone mineral density in newly diagnosed inflammatory bowel disease patients in Korea. *J Gastroenterol Hepatol.* 2000;15(5):512-8.
22. Ehrlich PJ, Lanyon LE. Mechanical strain and bone cell function: a review. *Osteoporos Int.* 2002;13(9):688-700
23. Bonewald LF, Johnson ML. Osteocytes, mechanosensing and Wnt signaling. *Bone.* 2008; [42\(4\): 606–615.](#)
24. Sawakami K, Robling AG, Ai M, Pitner ND, Liu D, Warden SJ, et al. The Wnt co-receptor LRP5 is essential for skeletal mechanotransduction but not for the anabolic bone response to parathyroid hormone treatment. *J Biol Chem.* 2006; 281(33):23698-711.
25. Hsu YH, Venners SA, Terwedow HA, Feng Y, Niu T, Li Z, et al. Relation of body composition, fat mass, and serum lipids to osteoporotic fractures and bone mineral density in Chinese men and women. *Am J Clin Nutr.* 2006; 83(1):146-54.
26. Pollock NK, Laing EM, Baile CA, Hamrick MW, Hall DB, Lewis RD. Is adiposity advantageous for bone strength? A peripheral quantitative computed tomography study in late adolescent females. *Am J Clin Nutr.* 2007; 86(5):1530-8.
27. Rosen CJ, Bouxsein ML. Mechanisms of disease: is osteoporosis the obesity of bone? *Nat Clin Pract Rheumatol* 2006; ;2(1):35-43.
28. Bernstein CN, Leslie WD, Taback SP: Bone density in a population-based cohort of premenopausal adult women with early onset inflammatory bowel disease. *Am J Gastroenterol* 2003.
29. Cao JJ. Effects of obesity on bone metabolism. *J Orthop Surg Res.* 2011; 6: 30. doi: [1186/1749-799X-6-30](#)

30. 30. Su Y, Leung J, Hans D, Aubry-Rozier B, Kwok T. Added clinical use of trabecular bone score to BMD for major osteoporotic fracture prediction in older Chinese people: the Mr. OS and Ms. OS cohort study in Hong Kong. *Osteoporos Int.* 2017;28(1):151-60.
31. 31. Nassar K, Paternotte S, Kolta S, Fechtenbaum J, Roux C, Briot K. Added value of trabecular bone score over bone mineral density for identification of vertebral fractures in patients with areal bone mineral density in the non-osteoporotic range. *Osteoporos Int.* 2014;25(1):243-9.

## Tables

Table 1: Classification of the TBS\* value

TBS Value	Classification
T score $\leq 1.200$	High risk of fracture (fully degraded microarchitecture)
$1.200 < \text{T score} < 1.350$	Intermediate risk (partially degraded microarchitecture)
T score $\leq 1.350$	Normal

\*TBS: Trabecular Bone Score

Table 2. Basic characteristics of the studied patients with Inflammatory Bowel Disease (IBD)

Age, mean (SD*); years	40.68 (12.22)
Gender, N (%)	
Male	30 (44.1)
Female	38 (55.9)
BMI <sup>†</sup> , mean (SD), kg/m <sup>2</sup>	26.45 (4.51)
Waist circumference, mean (SD), cm	89.97 (10.56)
Waist circumference, cm, N (%)	
Normal	28 (41.4)
≥90 in males, ≥80 in females	40 (58.8)
Abdominal circumference, mean (SD), cm	99.06 (10.78)
Disease duration, mean (SD), years	6.81 (7.20)
Final diagnosis, N (%)	
Ulcerative Colitis	56 (82.4)
Crohn's Disease	10 (14.7)
Undifferentiated	2 (2.9)
Disease duration, years, N (%)	
<5	35 (51.5)
5-10	14 (20.6)
≥ 10	19 (27.9)
BMD, N (%)	
Normal (> -1)	28 (41)
Low Bone Mass (-2.5 to -1)	34 (50)
Osteoporosis (< -2.5)	6 (9)
TBS <sup>¶</sup> , N (%)	
NL (>1.350)	47 (69)
PDM (1.250-1.350)	14 (21)
FDM (< 1.250)	7 (10)
FRAX <sup>#</sup> -Adjusted-MOF <sup>**</sup> ; mean (SD)	4.06 (3.14)

\*SD: Standard Deviation

<sup>†</sup>BMI: Body Mass Index

<sup>§</sup>BMD: Bone Mineral Densitometry

<sup>¶</sup>TBS (T-score): Trabecular Bone Score

<sup>#</sup> FRAX: Fracture Risk Assessment Tool

<sup>\*\*</sup>MOF: Major Osteoporotic Fracture

Table 3. Comparing the results of lumbar Bone Mineral Density and Trabecular Bone Score in patients with Inflammatory Bowel Disease (IBD)

	N	TBS <sup>†</sup>			P
		Normal (T-score > 1.350)	PDM <sup>‡</sup> (1.250 < T-score < 1.350)	FDM <sup>§</sup> (T-score < 1.250)	
ID*	Normal (> -1)	28 (41)	25 (53)	3 (21)	0.007
	Low density (-2.5 to -1)	34 (50)	20 (42)	9 (64)	
	Osteoporosis (< -2.5)	6 (8)	2 (4)	2 (14)	
Total		68 (10)	47 (100)	14 (100)	7 (100)

\*BMD: Bone Mineral Densitometry

†TBS: Trabecular Bone Score

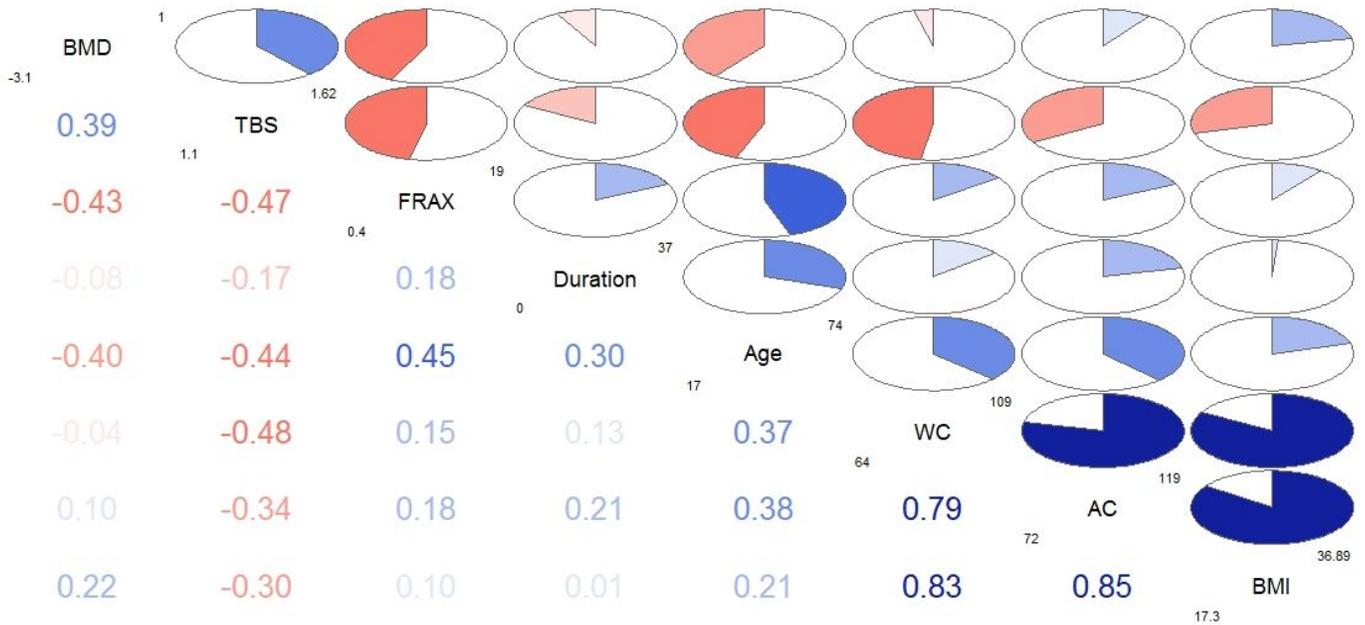
‡PDM: Partially Degraded Microarchitecture

§FDM: Fully Degraded Microarchitecture

Table 4. Mean (SD) of Trabecular Bone Score, FRAX and lumbar Bone Mineral Density (BMD) in patients Inflammatory Bowel Disease (IBD) regards to the sex and type of IBD

		TBS Mean (SD)	FRAX-Adjusted-MOF Mean (SD)	BMD Mean (SD)
Sex	Male	1.397 (0.098)	2.936 (2.920)	-1.431 (0.855)
	Female	1.400 (0.121)	4.815 (3.145)	-0.987 (1.121)
P-value		0.933	0.20	0.080
IBD group	UC	1.399 (0.114)	4.100 (3.247)	-1.144 (1.000)
	CD	1.406 (0.100)	3.711 (3.075)	-1.4800 (1.053)
P-value		0.896	0.740	0.336

## Figures



**Figure 1**

The correlation between TBS, FRAX and BMD with demographic variables in IBD patients

## Supplementary Files

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