

# Osteoporoz Tanısında Yeni Yöntemler



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# Sunum içeriđi

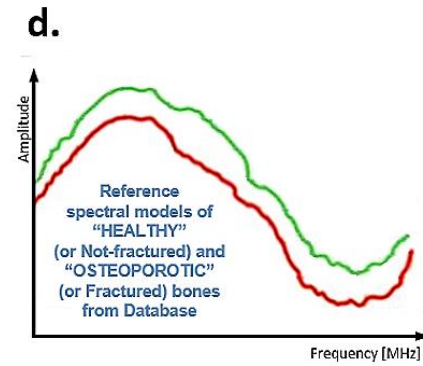
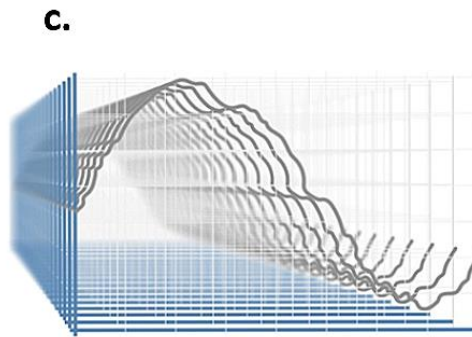
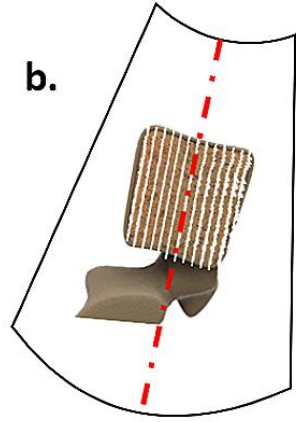
- REMS
- QCT
- Fırsatçı taramalar
- DXA dan türeyen ölçümler
  - TBS
  - HSA
  - BSI

# Radyofrekans Ekografik Multispektrometre REMS

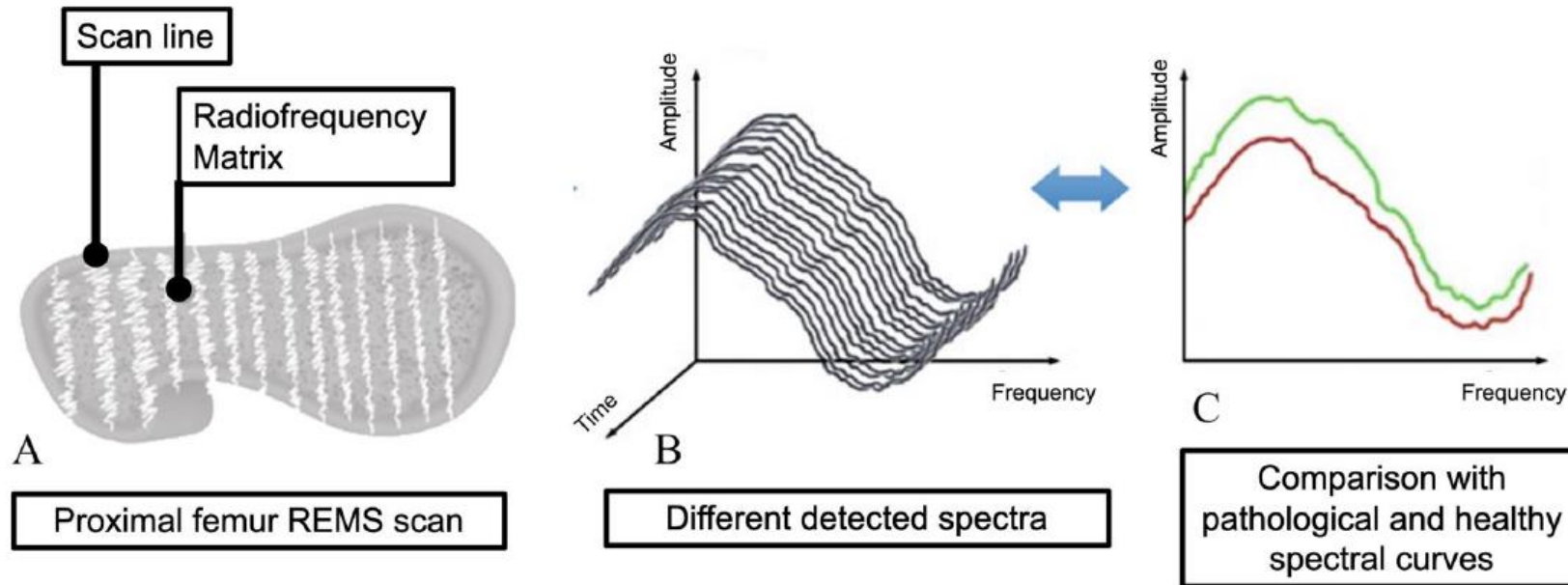
- Tüm veri işlenmemiş/filtre edilmemiş, yansıyan ultrason (RF) dalgalarından gelir
- Mevcut ultrason cihazları yansıyan dalganın sınırlı bir kısmını kullanarak B-mode görüntü oluşturur
- REMS tüm yansıyan RF den kemik yüzeyden gelenleri ayırır
  - Kortikal ve trabeküler değerlendirme

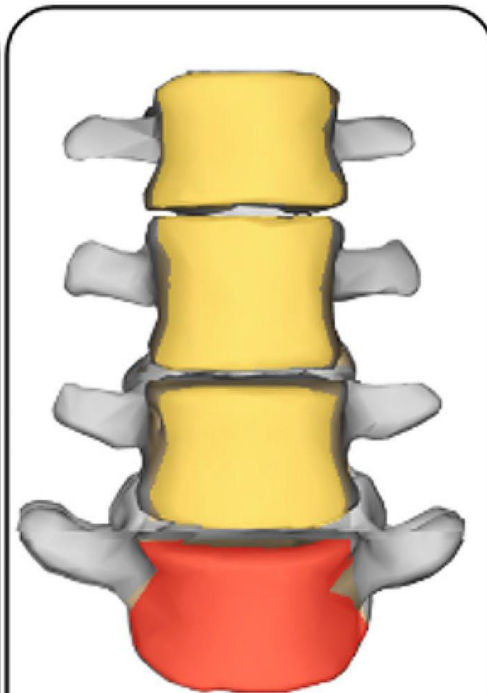
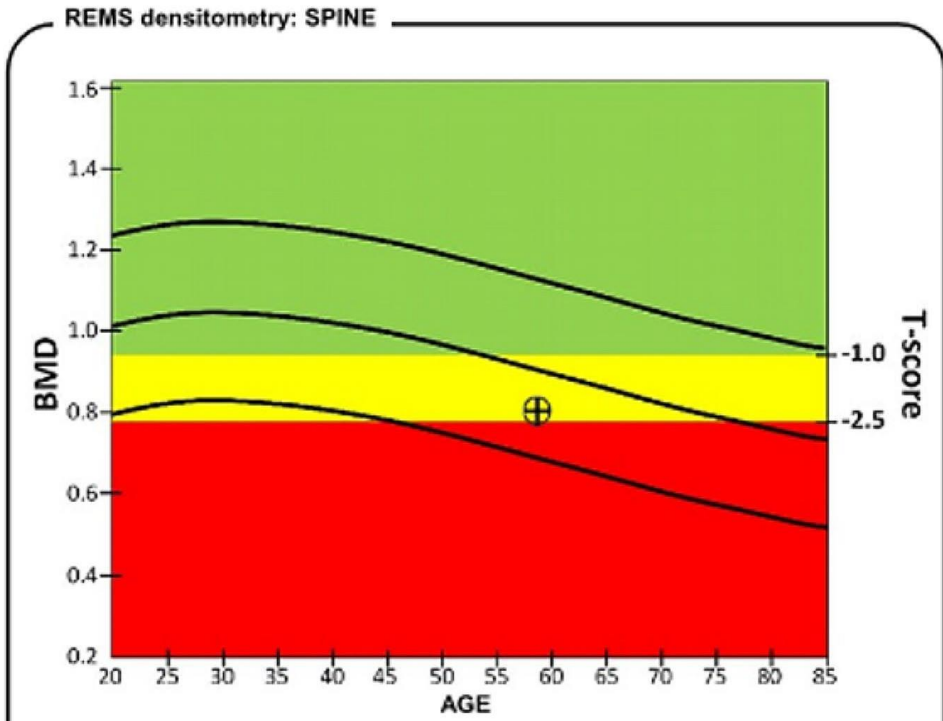
- Uygulayıcı scan derinliğini ayarlar
  - Obes/normal/zayıf
- Vertebra veta femur kortikal yüzeyi görüntüler
- Fokus kortikal kemiğin hemen altına gelecek şekilde ayarlanır
- Software otomatik olarak ROI belirler





- e.**
- |  |   |
|--|---|
| <p><b>Quantitative</b></p> <ul style="list-style-type: none"> <li>• BMD</li> <li>• T-score</li> <li>• Z-score</li> </ul> | <p><b>Qualitative</b></p> <ul style="list-style-type: none"> <li>• Fragility Score</li> </ul> |
|--|---|





	BMD (g/cm <sup>2</sup> )	T-score	Z-score	Diagnosis
<b>Total</b>	<b>0.797</b>	<b>-2.3</b>	<b>-0.9</b>	<b>Osteopenia</b>

	BMD	T-SCORE
L1	0.708	-2.0
L2	0.777	-2.3
L3	0.84	-2.2
L4	0.826	-2.6

**Fracture Risk Assessment**

Frailty Score - Spine	26.5/100
5-year Risk of Major Osteoporotic Fracture	10-20%

# Radyofrekans Ekografik Multispektrometre REMS

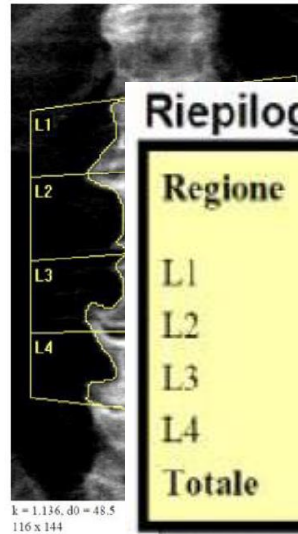
- Radyasyon içermez
- Taşınabilir
- OP tanı ve monitorizasyonu
- Lomber vertebra
- Femur (boyun, total femur, trokanter)
- DXA ve REMS BMD ölçümleri arasında güçlü korelasyon var
- REMS fragilite skoru ile 5 yıllık kırık riski tahmini



- Gebelerde/ çocuklarda kullanım
- Sık ölçüm yapılabilme
- Ölçüm bölgesi artefaktları ortadan kaldırılabilir
- DXA ya ek/tamamlayıcı veya alternatif

(A) DXA scan

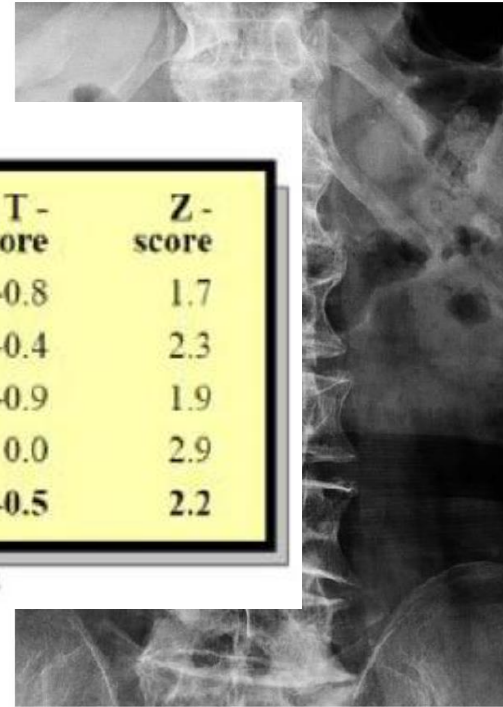
(B) X-Ray scan



**Riepilogo risultati DXA:**

Regione	Area (cm <sup>2</sup> )	BMC (g)	BMD (g/cm <sup>2</sup> )	T - score	Z - score
L1	15.75	14.29	0.907	-0.8	1.7
L2	16.11	15.93	0.989	-0.4	2.3
L3	17.44	17.17	0.984	-0.9	1.9
L4	19.73	20.86	1.057	0.0	2.9
<b>Totale</b>	<b>69.04</b>	<b>68.24</b>	<b>0.988</b>	<b>-0.5</b>	<b>2.2</b>

Totale BMD CV 1.0%, ACF = 1.047, BCF = 1.014, TH = 7.184



(C) REMS scan

Densitometria ultrasonica: COLONNA



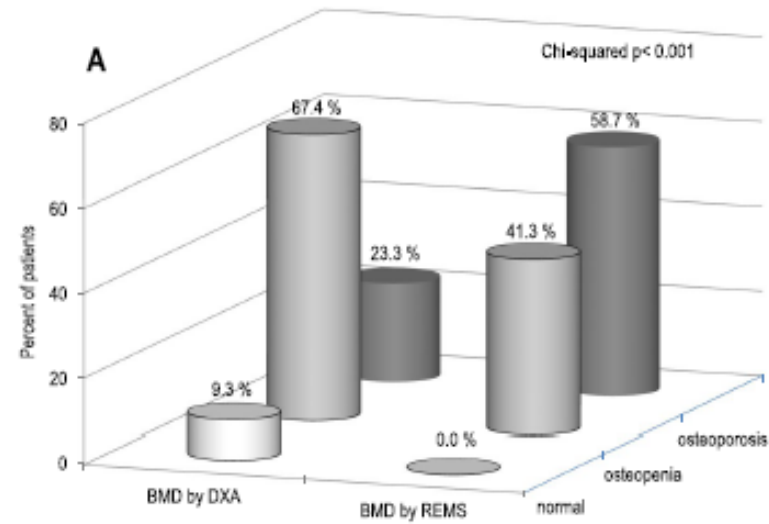
	BMD (g/cm <sup>3</sup> )	T-score	Z-score	Diagnosi	Rischio di frattura
<b>Totale</b>	<b>0.778</b>	<b>-2.4</b>	<b>-0.1</b>	<b>Osteopenia</b>	<b>Medio</b>

FRAX® - Probabilità di frattura a 10 anni		
Principali osteoporotiche	39.45	%
Frattura d'anca	21.14	%

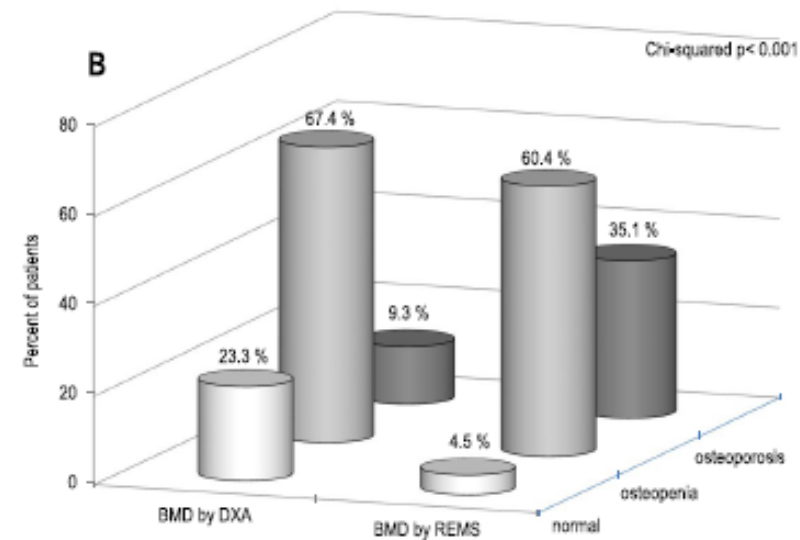
Totale	0.778	-2.4	-0.1	Osteopenia	Medio
FRAX® - Probabilità di frattura a 10 anni					
Principali osteoporotiche	39.45	%			
Frattura d'anca	21.14	%			

L1	0.672
L2	0.722
L3	0.808
L4	0.886

Kırıklar



OA



**Fig. 4** Percentage of fractured subjects classified as "osteoporotic", "osteopenic" or "normal" on the basis of BMD T-score values obtained by DXA and REMS technique in subjects with fractures (A) and in subjects with osteoarthritis at the lumbar spine (B)

- REMS tutarlılık ve keskinliği
  - BMD ile tanımlı OP da
    - Femur boynu sensitivite %91.5, spesifite %91.8
    - Lomber vertebra sensitivite %91.7, spesifite %92
  - İntraoperator variabilite %0.32-%0.38
  - İnteroperator variabilite %0.48-%0.54
  - REMS BMD T-skoru ile DXA T-skoru arası korelasyon
    - Lomber vertebra  $r=0.94$
    - Femur boynu  $r=0.93$

- Tekrar edilebilirlik ve keskinlik deęerleri
  - Tedavinin kısa dönem monitorizasyonunda kullanılabilir
  - Dięer BMD ölçüm yöntemlerinde bu süre en az 1 yıl
- REMS
  - Aromataz inhibitörü kullananlarda 6 ayda
  - Denosumab kullananlarda 6 ayda

## Key Advantages

DXA

QUS

EchoStation

Radiation Exposure

YES

NO

NO

Axial Sites

YES

NO

YES

Bone Density Assessment BMD (g/cm<sup>2</sup>)

YES

NO

YES

Bone Quality Assessment

NO

??

YES

FRAX Index

YES

NO

YES

Body Composition Index

YES

NO

YES

Operator Independent

NO

NO

YES

Accuracy

HIGH

LOW

VERY HIGH

Primary Care

NO

YES

YES

Cost

HIGH

VERY LOW

LOW

Operator Certified Needed

YES

NO

NO

Dedicated Shield Room

YES

NO

NO

Maintenance Costs

YES

NO

NO

Diagnostic Tool

YES

NO

YES

Prevention, Monitoring and Follow-up

NO

NO

YES

# QCT

- İlk kantitatif deęerlendirme yöntemlerinden biri
  - 1970 sonları
  - 1980 lerde BMD ölçümünde standart yöntem olduğuna dair ilk yayınlar
- Günümüzde DXA ya önemli bir alternatif
  - Volümetrik ölçüm
  - Omurga ve kalçanın daha iyi morfometrik deęerlendirilmesi
  - Kortikal kemik ve trabeküler kemik deęerlendirilmesi
  - FEM

	Analysis options				Comment
	Spine	Hip	CTXA <sup>a</sup>	Geometry	
QCT Pro: Mindways Inc	trab BMD of central elliptical VOI	int, trab, cort, BMD/BMC/vol of neck, trochanter, IT, and total hip	Yes	Hip: cortical thickness	BIT: analysis of 2D slices in the neck and the trochanter
VirtuOst: O.N. Diagnostics	trab BMD of central elliptical VOI	int BMD of the total hip	Yes		FEM analysis software that outputs few BMD values
MIAF: University of Erlangen	int, trab, cort, subcort BMD/BMC/vol of multiple VOIs of the vertebral body	int, trab, cort, subcort BMD/BMC/vol of head, neck, trochanter, IT, shaft, and total hip	No	Hip and spine: cortical thickness, moments of inertia	Analysis of 2D slices in the neck and the trochanter
Stradwin: University of Cambridge		trab/cort BMD, cortical mass per projected surface area of the total hip		Hip: cortical thickness	Cortical thickness mapping <sup>b</sup>
UCSF QCT analysis software	int, trab, cort, BMD/BMC/vol of multiple VOIs of vertebral body	int, trab, cort, BMD/BMC/vol of the neck and the trochanter	Yes		

*Note:* Web pages for the analysis programs are listed in the Appendix.

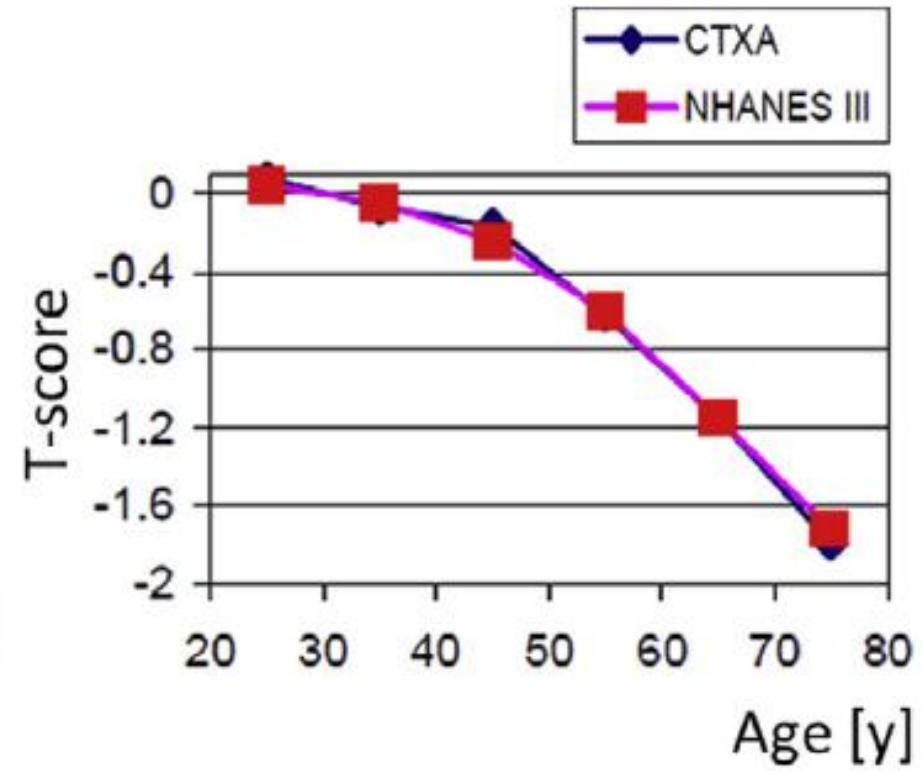
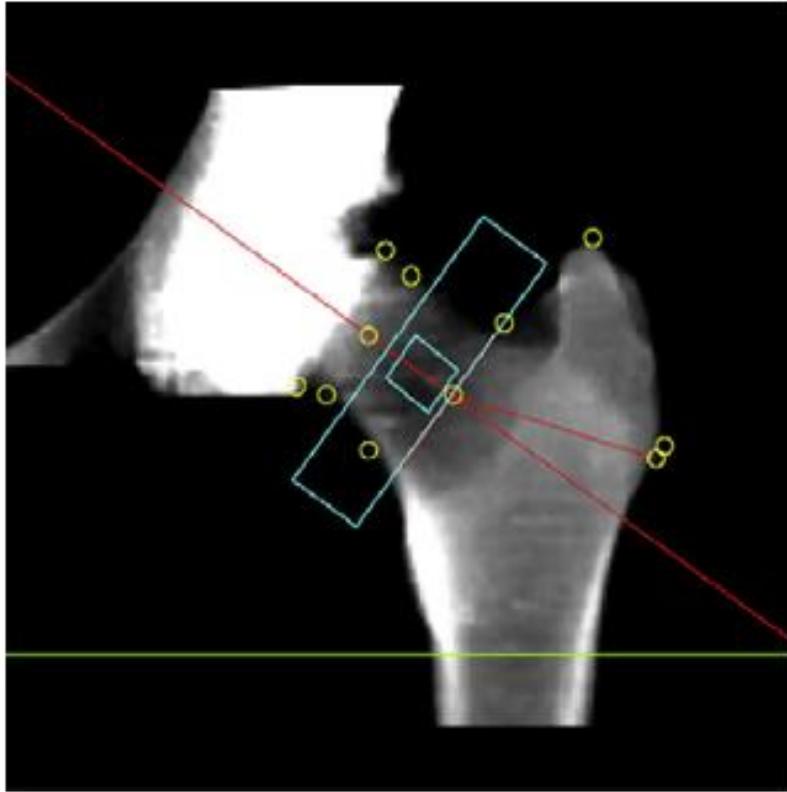
*Abbr:* 2D, 2-dimensional; BIT, bone investigational toolkit for QCT Pro; BMC, bone mineral content; BMD, bone mineral density; cort, cortical; CTXA, computed tomography X-ray absorptiometry; FEM, finite element analysis; int, integral; IT, intertrochanter; QCT, quantitative computed tomography; subcort, subcortical (VOI between cortical and trabecular compartments); trab, trabecular; VOI, volume of interest; vol, volume.

<sup>a</sup>CTXA details are discussed in the section “CTXA–DXA Equivalent *T*-Scores From QCT.”

<sup>b</sup>Details are discussed in the section “Cortical Bone-Continuing Challenges.”



# CTXA



# CTXA<sup>TM</sup> Hip Bone Mineral Densitometry

Name: Hasta Adı, Soyadı

Sex: Female

DOB: 02.01.1950

ID: 433373

Radiologist:

Age: 68

Date: 19.02.2018

Exam: 1

Referring Physician:

Comments:

## Analysis Results

Hip Analyzed: Left

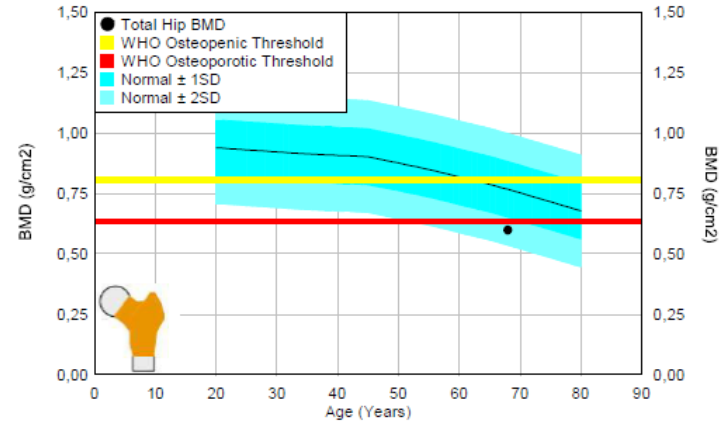
ROI	BMD (g/cm <sup>2</sup> )	T-Score	Z-Score
Total	0,599	-2,79	-1,33
Neck	0,475	-2,89	-1,51
Trochanter	0,461	-2,31	-1,09
Intertrochanter	0,729	-2,68	-1,27
Wards	0,275	--	--

Reference Data: CTXA

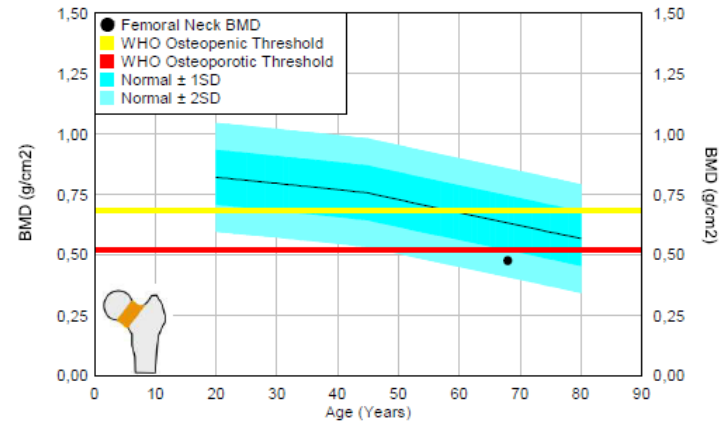
**Interpretation:** Dünya Sağlık Örgütü (WHO)'ne göre -2.5 den küçük toplam kalça T-Skor degeri, osteoporoz olarak tanımlanmaktadır.

### The WHO classification criteria for T-scores

T-score	Classification
greater than -1.0	Normal
between -1.0 and -2.5	Osteopenia
below -2.5	Osteoporosis
below -2.5 with fracture	Severe Osteoporosis



Patient BMD Value Compared to Age-Matched CTXA Total Hip Reference Data



Patient BMD Value Compared to Age-Matched CTXA Femoral Neck Reference Data

# 3D QCT Bone Mineral Densitometry

Name: SOYADI, HASTA ADI

Sex: Female  
Age: 59  
Comments:

DOB: 25.9.1952  
Date: 31.8.2012  
Exam: 1

Radiologist:  
Referring Physician:

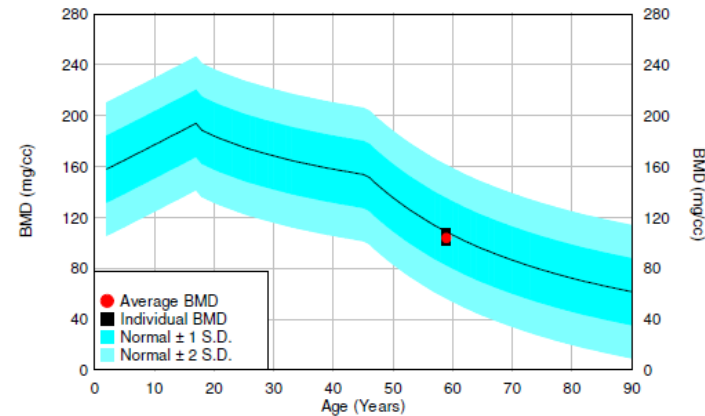
## Analysis Results

ROI	BMD (mg/cm <sup>3</sup> )	T-Score (DXA)	T-Score (QCT)	Z-Score
T11	-	-	-	-
T12	-	-	-	-
L1	-	-	-	-
L2	107,8	-1,5	-2,3	0,0
L3	102,4	-1,7	-2,5	-0,2
L4	101,3	-1,7	-2,6	-0,3
<b>Average:</b>	<b>103,8</b>	<b>-1,61</b>	<b>-2,5</b>	<b>-0,19</b>
Age Matched Normal (UCSF):			108,7 ± 26	

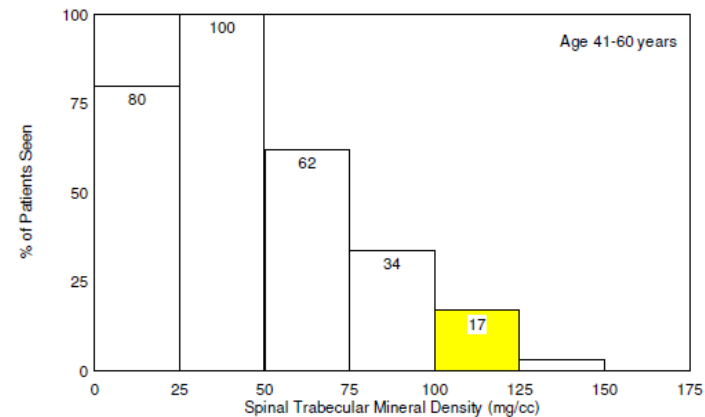
**T-Score Method:** Calculated by a linear mapping of QCT BMD values to T-scores with reference to American College of Radiology (ACR) guidelines. A BMD value of 120mg/cm<sup>3</sup> is mapped to a T-score of -1.0 and 80mg/cm<sup>3</sup> is mapped to a T-score of -2.5.

### The WHO classification criteria for T-scores

DXA T-score	Classification
greater than -1.0	Normal
between -1.0 and -2.5	Osteopenia
below -2.5	Osteoporosis
below -2.5 with fracture	Severe Osteoporosis



Patient BMD Value Compared to Age and Sex Matched Control Data (UCSF)



Prevalence of Vertebral Compression Fractures in Untreated Postmenopausal Women Scanned at UCSF

- Tanı
  - Femur boynu ve total kalça skorları (2 boyuntlu projeksiyon) ilgili DXA skorlarına eşitir. WHO kriterlerine göre tanı konulabilir
- Kırık riski belirleme
  - QCT ile ölçülen Spinal trabeküler BMD kadınlarda DXA kadar kırık riskini belirler. Erkeklerde veri yetersiz
- Tedavi kararı
  - DXA yoksa QCT ye göre verilebilir
- Monitoring
  - Hastalık veya tedavi ile ilgili değişikliklerin izlenmesi için kullanılabilir

# Fırsatçı Tarama (Opportunistic Screening)

- FT, başka bir klinik amaçla istenmiş CT-MR görüntülerinin sonradan diğer bir amaç için kullanılması (pelvis, abdomen, AC)
  - Mevcut CT görüntülerinin kırık riski yüksek OP hastalarının belirlenmesi amacıyla kullanımı
- Tomografi görüntülerinin yeniden değerlendirilmesi ile kırık tanısı
  - Koronal/Sagittal?
  - Kaç kesit ortalaması?
  - Skolyoz?
  - Kifoza?

Pseudo X-ray from CT  
average 200 slices  $\approx$  8 cm

Original CT

average  
10 slices  $\approx$  0.4 cm



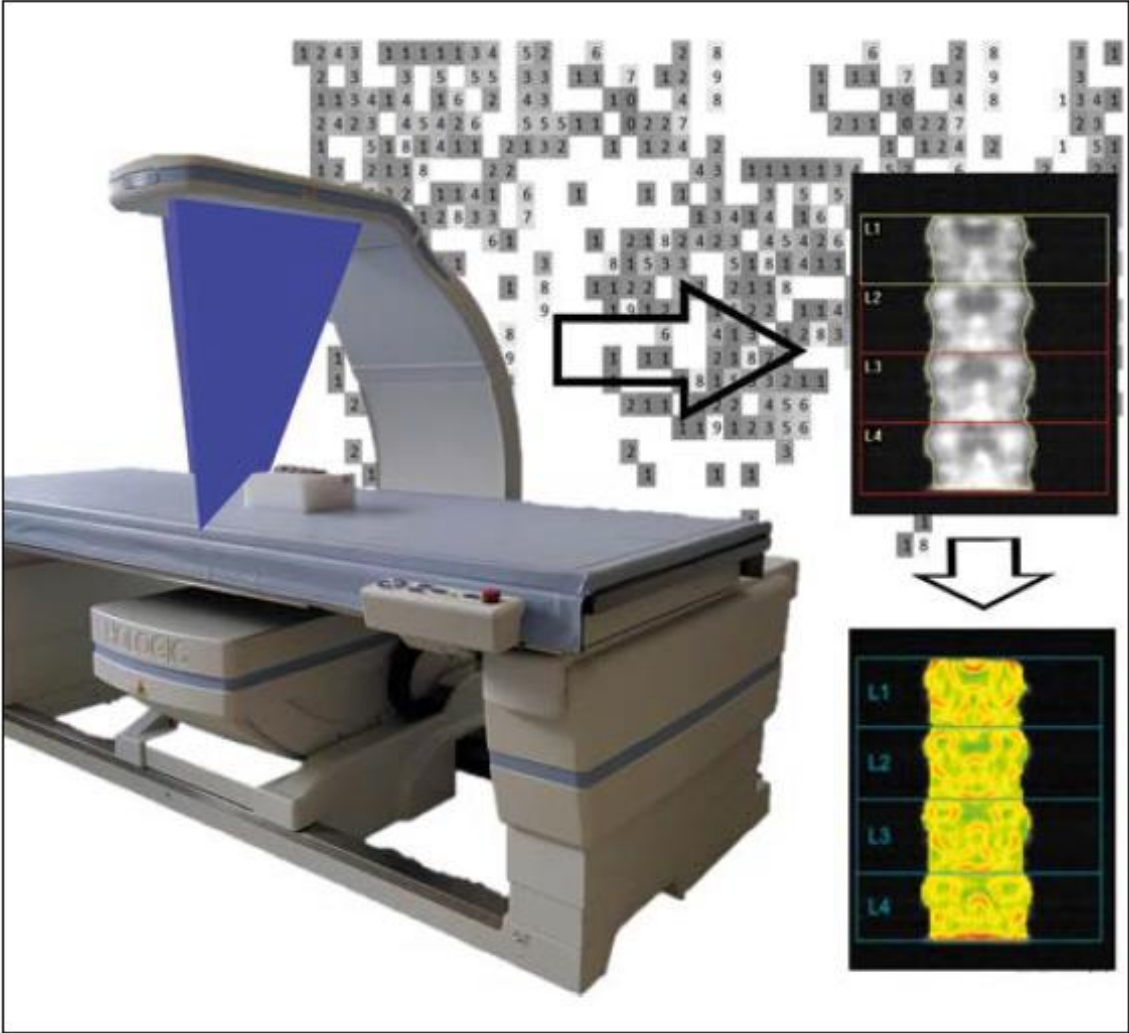
- Kontrast kullanılırsa miktarına bağı sonuç etkilenir
- Kortikal ve trabeküler kemikteki etki farklıdır
- Fantom???
- ISCD
  - Stabilitesi sağlanmış Scanner
  - Cutoff değerleri belirlenmiş ve validasyonu yapılmış makinelerde
    - Düşük BMD, Omurga ve Femurda düşük kemik gücü taraması

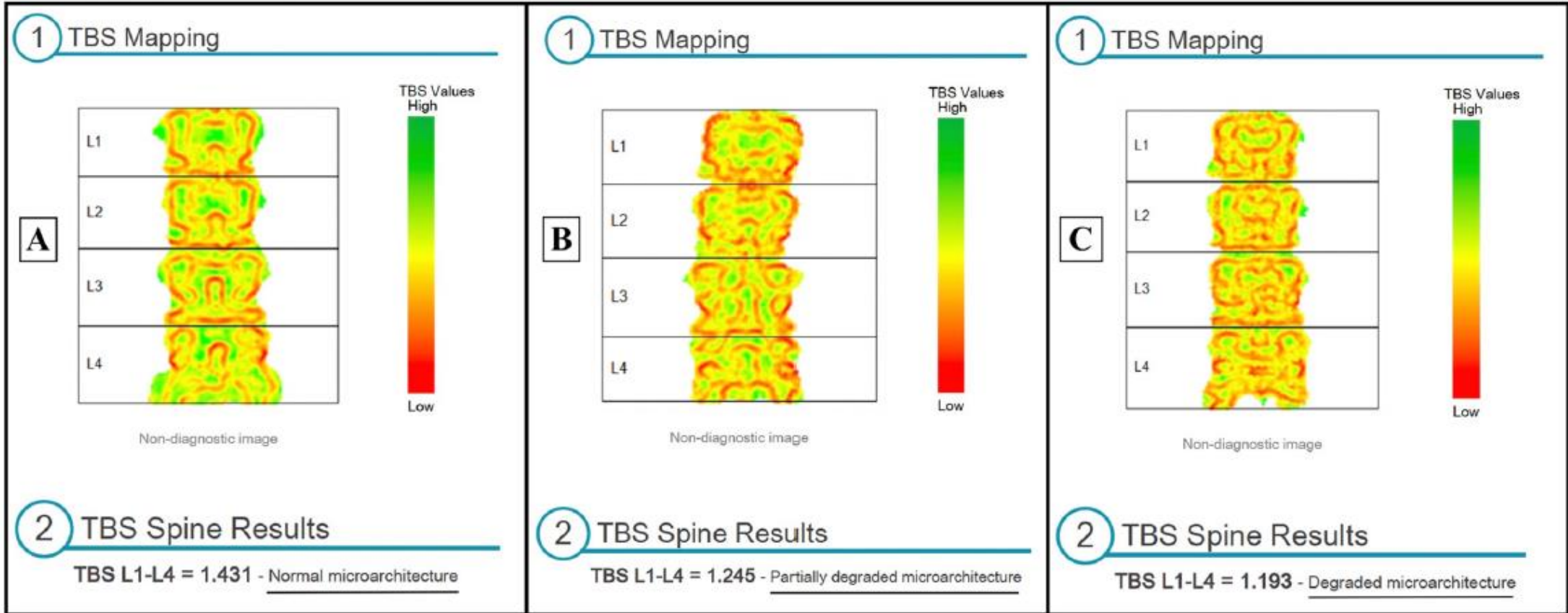
BMD calibration	Calibration phantom	Advantages	Disadvantages	Analogous DXA technique
Simultaneous external	Yes	Correction of all scanner instabilities that affect the patient and the phantom in the same way	Phantom not in the same position as the bone to be measured, difference in X-ray field inhomogeneities not fully corrected	Hologic (calibration wheel)
Asynchronous external	Yes	Phantom can be scanned in the same position as the bone to be measured.	Short scanner instabilities that occur between phantom measurements are not detected and are not corrected	GE-Lunar/Norland (phantom scanned separately from patient)
Simultaneous internal	No	Internal tissues close to the bone to be analyzed are used, potentially independent of table height.	Details have not been published yet, scientific validation not possible, potentially scanner-specific constants have to be considered	
None	No	No additional effort	Use of CT instead of BMD values, CT values are scanner specific, not comparable across devices, normative data from other scanners cannot be used, scanner stability insufficiently monitored for BMD measurements	

*Abbr:* BMD, bone mineral density; CT, computed tomography; DXA, dual-energy X-ray absorptiometry.



# TBS

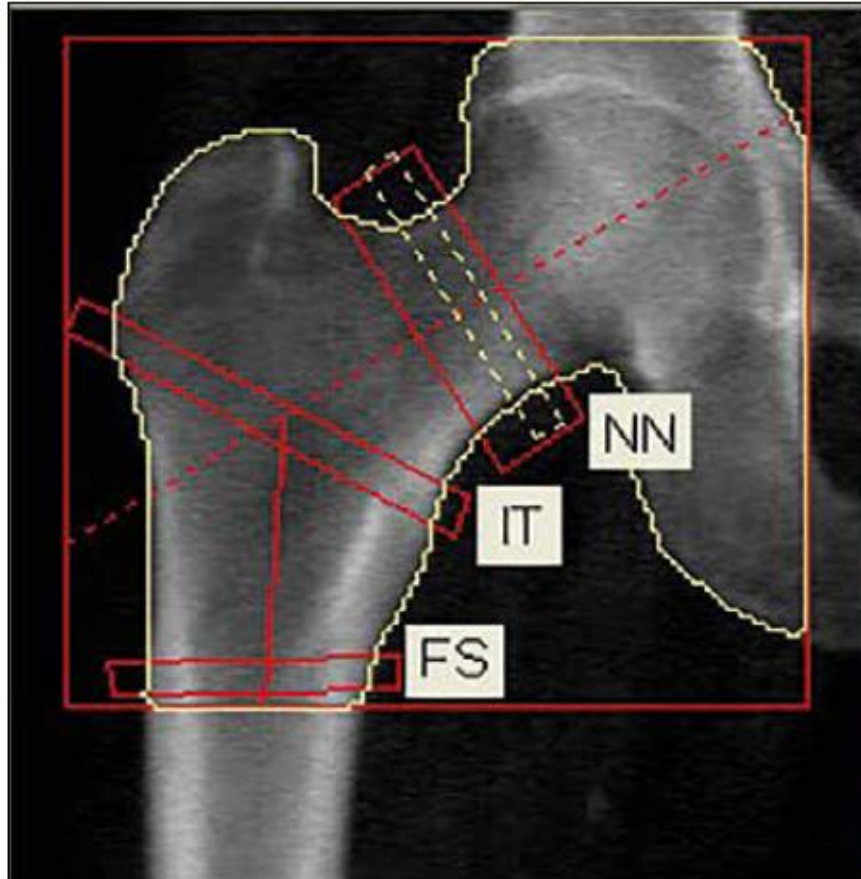




>1.31 normal, 1.23-1.31 kısmen bozulmuş mikromimari, <1.23 bozulmuş mikromimari artmış kırık riski

- TBS PM kadınlarda vertebra kalça ve majör OP kırık riski ile ilişkilidir
- TBS 50 yaş üstü erkeklerde kalça kırık riski ve majör OP kırık riski ile ilişkilidir
- TBS klinik pratikte tek başına tedavi önerisi için kullanılmaz.
- TBS in FRAX ile birlikte kullanılması kırık riskinin daha iyi belirlenmesine faydalıdır
- Tedavi alan hastalarda
  - Anti resorptif tedavi alanlarda monitorizasyonda kullanımı açık değildir
  - TBS anabolik tedavinin monitorizasyonunda potansiyel faydalıdır
- TBS tip II DM lu PM kadınlarda majör OP kırık riski ile ilişkilidir

# HSA



Region	CSA (cm <sup>2</sup> )	CSMI (cm <sup>2</sup> ) <sup>2</sup>	Z (cm <sup>3</sup> )	Cort (cm)	BR
NN	2.60	1.91	1.04	0.16	11.4
IT	4.52	11.82	3.87	0.34	9.0
FS	4.05	3.65	2.30	0.48	3.3

Neck Shaft Angle: 125°  
Hip Axis Length: 110 mm

CSA = cross-sectional area  
CSMI = cross-sectional moment of inertia  
Z = section modulus  
Cort = cortical thickness  
BR = buckling ratio

- HAL PM kadınlarda kalça kırık riski ile ilişkilidir
- DXA dan elde edilen kalça geometri parametreleri (CSA, OD, SM, BR, CSMI, NSA) kırık riskini değerlendirmek ve tedavi kararı ve monitorizasyon için kullanılmaz.

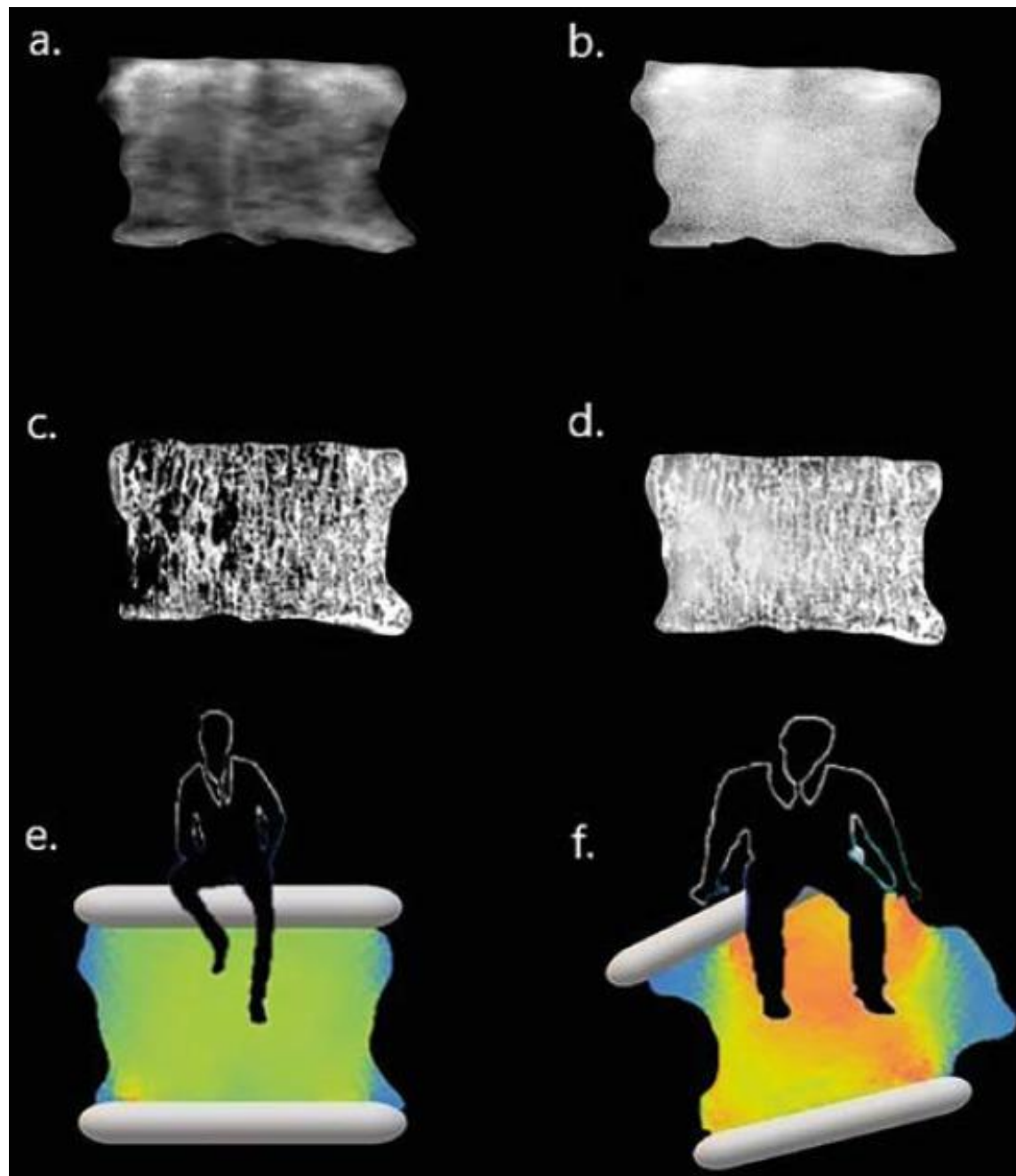
# Bone Strain Index (BSI)

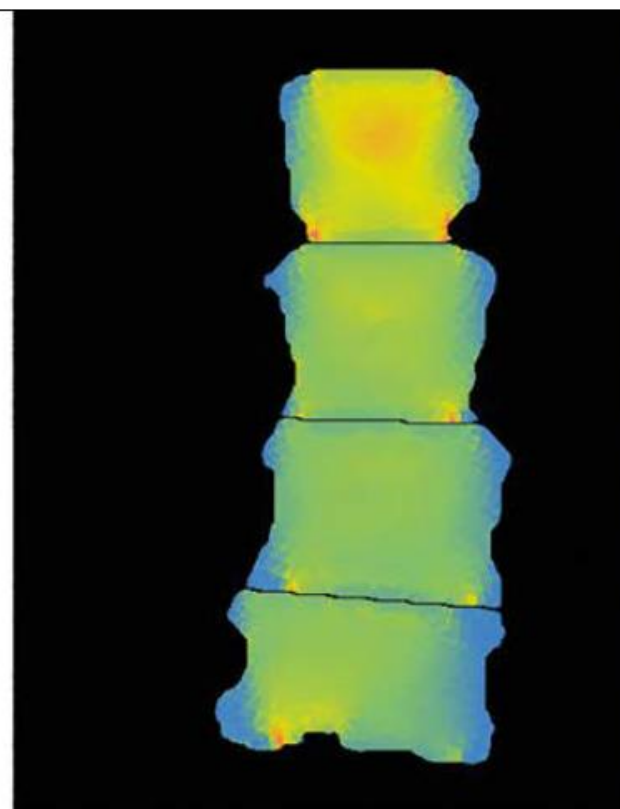
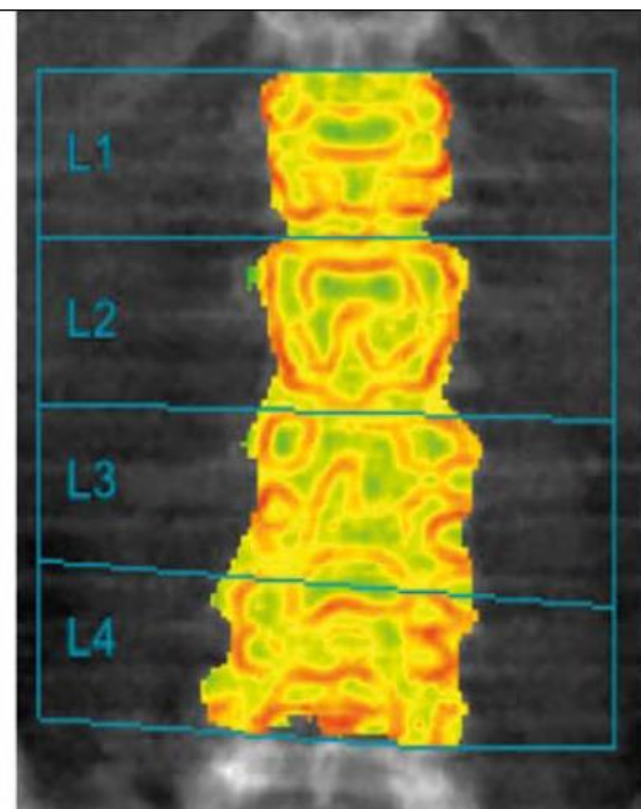
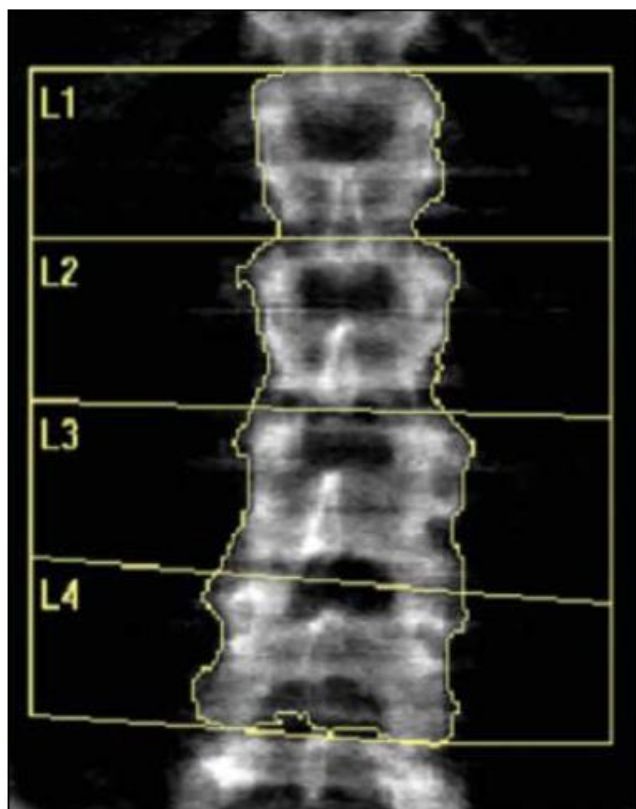
- DXA → kemik yoğunluğu
- TBS → mikromimari
- BSI kemik gücü ve dayanıklılığını (Yüklenmeye karşı direnci)
  - Finite element analizi
  - Software kemik gerilme oranını haritalandırır
  - Yüksek BSI değerleri yüksek gerilme oranı ve artmış kırık riski ile ilişkilidir

BMD

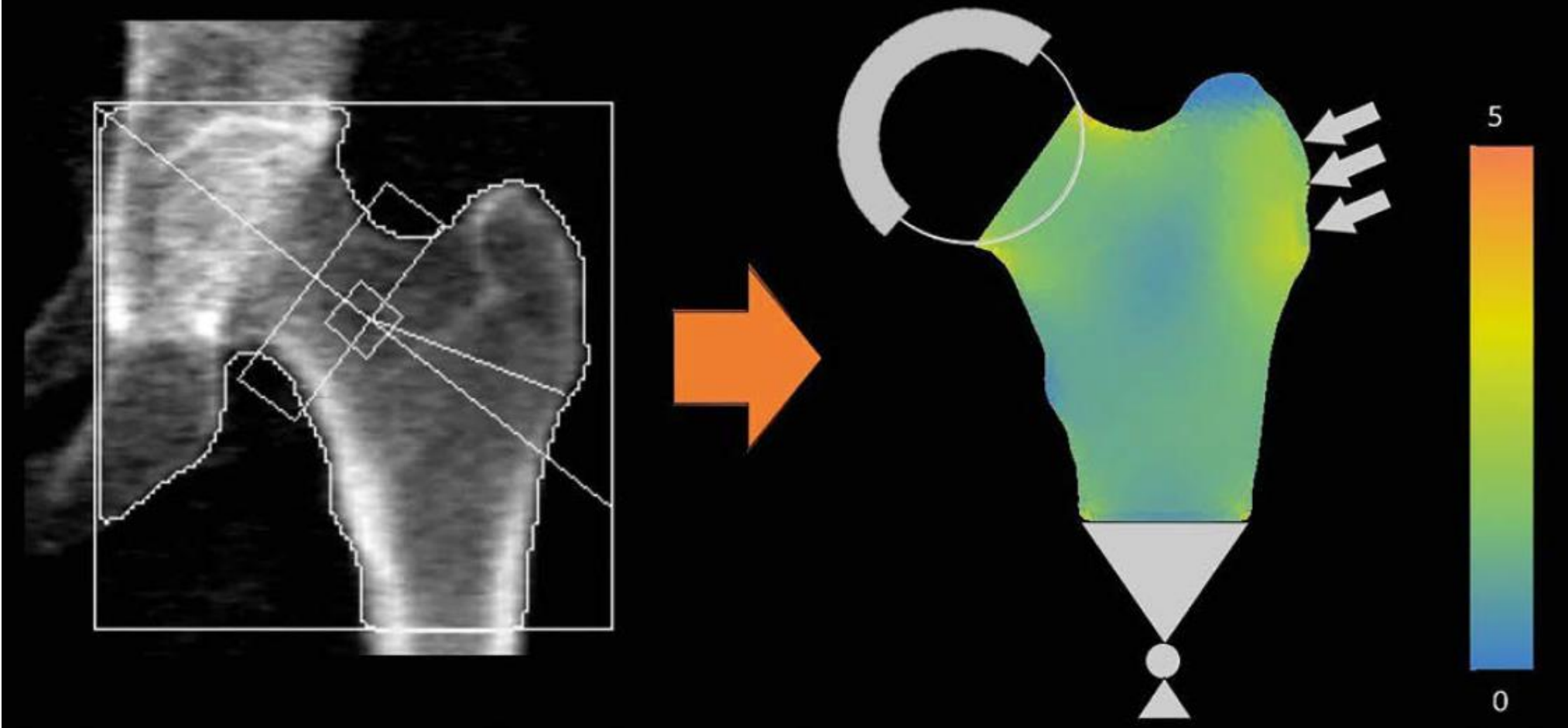
TBS

BSI

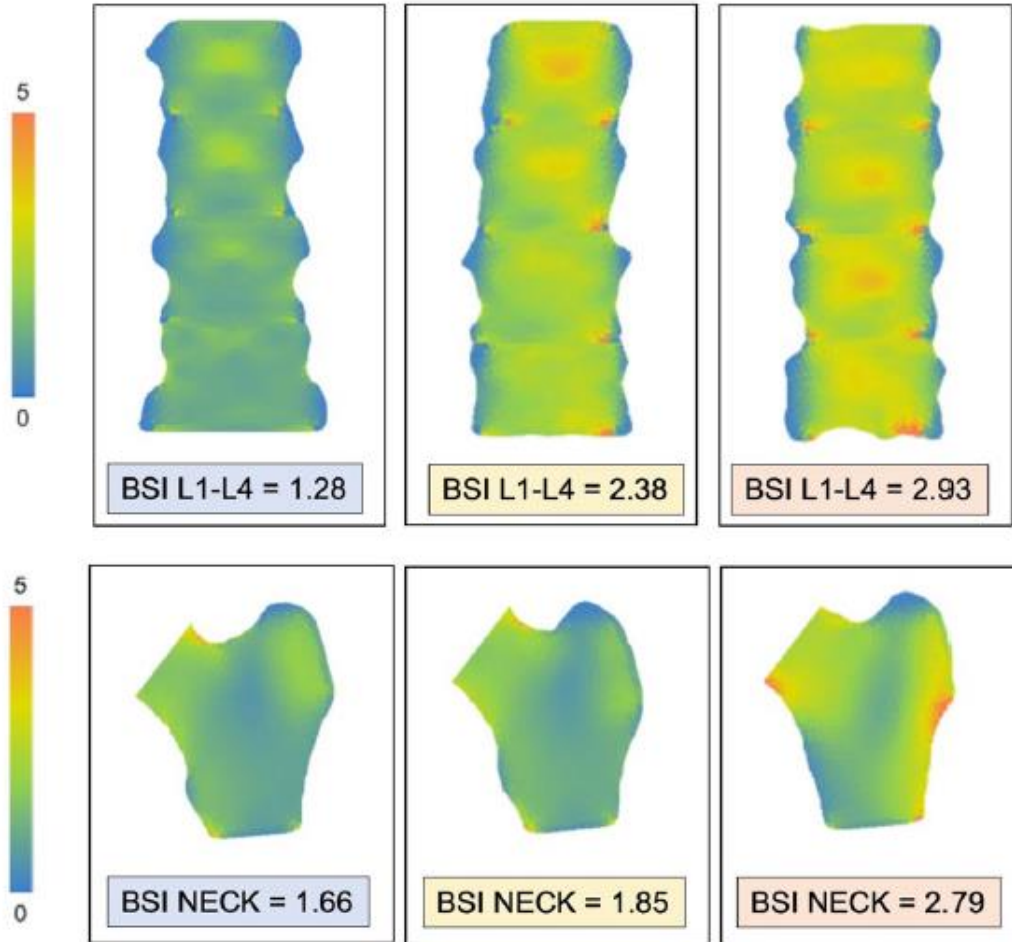








# BSI



BSI  
<1.7 normal  
1.7-2.5 straine düşük direnç  
>2.5 straine kötü direnç

