# ΟΤΙ ΝΕΟΤΕΡΟ ΑΠΟ ΤΗΝ ΑΠΕΙΚΟΝΙΣΗ ΤΟΥ ΣΚΕΛΕΤΟΥ

**ΚΩΝ/ΝΟΣ ΔΙΟΝ. ΣΤΑΘΟΠΟΥΛΟΣ M.D., Ph.D**
**ΟΡΘΟΠΑΙΔΙΚΟΣ ΧΕΙΡΟΥΡΓΟΣ**
**ΕΠΙΣΤΗΜΟΝΙΚΟΣ ΣΥΝΕΡΓΑΤΗΣ ΙΑΤΡΙΚΗΣ ΣΧΟΛΗΣ ΕΚΠΑ**
**ΠΜΣ "ΜΕΤΑΒΟΛΙΚΑ ΝΟΣΗΜΑΤΑ ΟΣΤΩΝ"**

# DXA: ΤΙ ΔΕΝ ΜΕΤΡΑΕΙ?

| *Factor* | *Variable* | *Method** |
|---|---|---|
| Bulk | BMC | DXA, (p)QCT, ashing |
| Morphology | | |
| Dimensions | Cortical wall thickness (mean and direction specific) | (p)QCT, μ-CT, MRI |
| | Cortical cross-sectional area | (p)QCT, μ-CT, MRI |
| | Total cross-sectional area | (p)QCT, μ-CT, MRI |
| | Diameters (max, min, other direction) | (p)QCT, MRI, (caliper) |
| | Trabecular cross-sectional area, marrow area | (p)QCT, μ-CT |
| | Axial length of whole bone/anatomic structures | Caliper, tape measure, radiograph, DXA, QCT, MRI |
| Geometry | Cross-sectional moment of inertia (max, min, other direction) | (p)QCT, μ-CT, MRI |
| | Eccentricity (shape of bone cross-section) | (p)QCT, MRI |
| | Center of mass (location) | (p)QCT, MRI |
| | Angle between distinct anatomic structures, curvature | Radiograph, DXA, QCT, MRI |
| Texture | | |
| | Cortical porosity (cortical apparent density) | μ-CT, SR-μ-CT [(p)QCT] |
| | Trabecular apparent density (~BV/TV) | (p)QCT, μ-CT, HR-MRI, histomorphometry |
| | Trabecular architecture and (micro)structure | μ-CT, HR-MRI, histomorphometry |
| | Mineralization | μ-CT, qBSE |
| | (Micro)damage | Confocal microscopy, histomorphometry |

* Not an exhaustive list. Evaluation of the given variable is mainly based on manual, semiau matic analysis of the scan (image) data of measured bone projection, cross-section or volume.

SR, synchrotron radiation; MRI, magnetic resonance imaging; HR, high resolution; qBSE,

# ΠΟΣΟΤΙΚΗ ΑΞΟΝΙΚΗ ΤΟΜΟΓΡΑΦΙΑ

- ΣΠΟΝΔΥΛΙΚΗ ΣΤΗΛΗ (QCT)
- ΙΣΧΙΟ (QCT)
- ΠΕΡΙΦΕΡΙΚΗ ΠΟΣΟΤΙΚΗ ΑΞΟΝΙΚΗ ΤΟΜΟΓΡΑΦΙΑ (pQCT) : ΚΕΡΚΙΔΑ, ΚΝΗΜΗ
- ΠΕΡΙΦΕΡΙΚΗ ΠΟΣΟΤΙΚΗ ΑΞΟΝΙΚΗ ΤΟΜΟΓΡΑΦΙΑ ΥΨΗΛΗΣ ΕΥΚΡΙΝΕΙΑΣ (High Resolution pQCT): ΚΕΡΚΙΔΑ, ΚΝΗΜΗ

*Journal of Clinical Densitometry: Assessment of Skeletal Health*, vol. 11, no. 1, 123–162, 2008

1094-6950/08/11:123–162/$34.00
DOI: 10.1016/j.jocd.2007.12.010

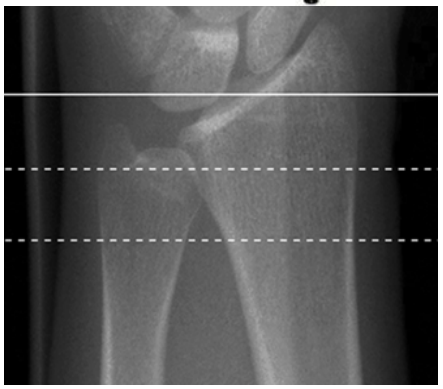
**Position Statement**

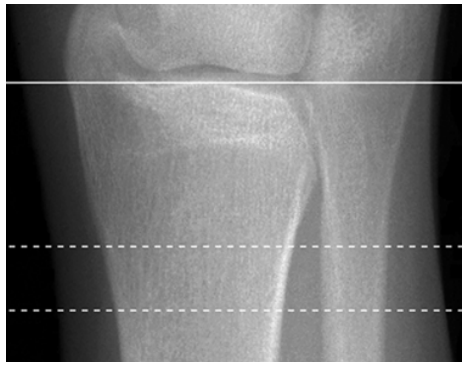
# Clinical Use of Quantitative Computed Tomography and Peripheral Quantitative Computed Tomography in the Management of Osteoporosis in Adults: The 2007 ISCD Official Positions

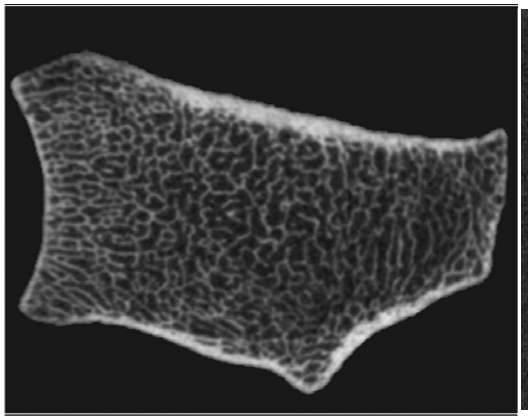
*Klaus Engelke,*[*1,2,a] *Judith E. Adams,*[3,b] *Gabriele Armbrecht,*[4,b] *Peter Augat,*[5,b] *Cesar E. Bogado,*[6,b] *Mary L. Bouxsein,*[7,b] *Dieter Felsenberg,*[8,b] *Masako Ito,*[9,b] *Sven Prevrhal,*[10,b] *Didier B. Hans,*[11,c] *and E. Michael Lewiecki*[12,c]

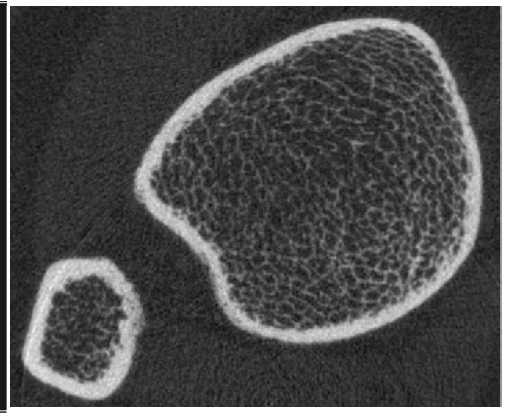
- ΤΡΙΣΔΙΑΣΤΑΤΗ ΤΕΧΝΙΚΗ
- ΔΙΑΚΡΙΣΗ ΣΠΟΓΓΩΔΟΥΣ-ΦΛΟΙΩΔΟΥΣ ΟΣΤΟΥ
- ΟΓΚΟΜΕΤΡΙΚΗ ΟΣΤΙΚΗ ΠΥΚΝΟΤΗΤΑ
- ΠΛΗΡΟΦΟΡΙΕΣ ΓΕΩΜΕΤΡΙΑΣ
- ΠΛΗΡΟΦΟΡΙΕΣ (ΜΙΚΡΟ)ΑΡΧΙΤΕΚΤΟΝΙΚΗΣ ΣΠΟΓΓΩΔΟΥΣ ΚΑΙ ΦΛΟΙΩΔΟΥΣ
- ΥΨΗΛΗ ΑΚΤΙΝΟΒΟΛΙΑ ΣΤΟΝ ΑΞΟΝΙΚΟ ΣΚΕΛΕΤΟ (ΣΣ, ΙΣΧΙΟ) vs ΠΟΛΥ ΧΑΜΗΛΗ ΑΚΤΙΝΟΒΟΛΙΑ ΣΤΟΝ ΠΕΡΙΦΕΡΙΚΟ ΣΚΕΛΕΤΟ (ΚΕΡΚΙΔΑ, ΚΝΗΜΗ)

# High Resolution pQCT









~ 80 $\mu m^3$ voxel size

~ 3 min scan time, < 4 µSv

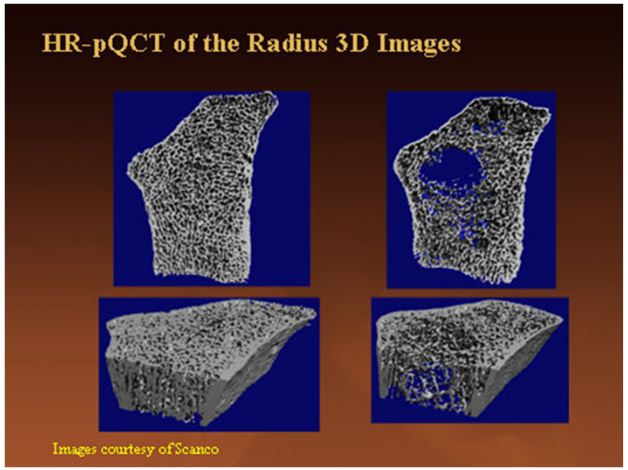
Distal radius and tibia only

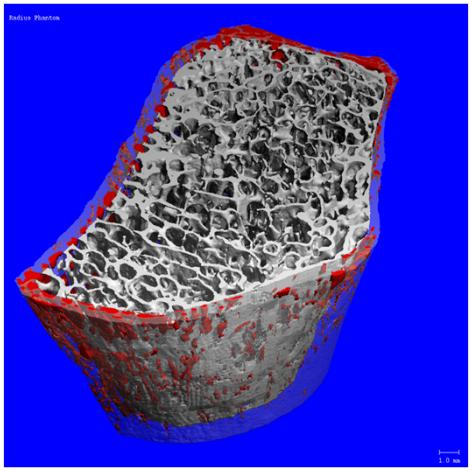
Reproducibility:

density: 0.7 - 1.5% *

µ-architecture: 1.5 - 4.4% *

# ΟΓΚΟΜΕΤΡΙΚΗ ΟΣΤΙΚΗ ΠΥΚΝΟΤΗΤΑ-ΜΙΚΡΟΑΡΧΙΤΕΚΤΟΝΙΚΗ ΣΠΟΓΓΩΔΟΥΣ/ΦΛΟΙΩΔΟΥΣ



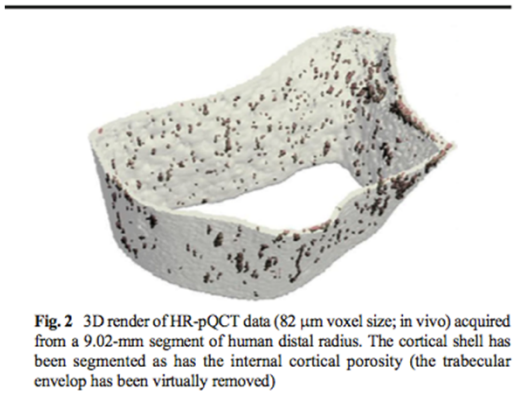
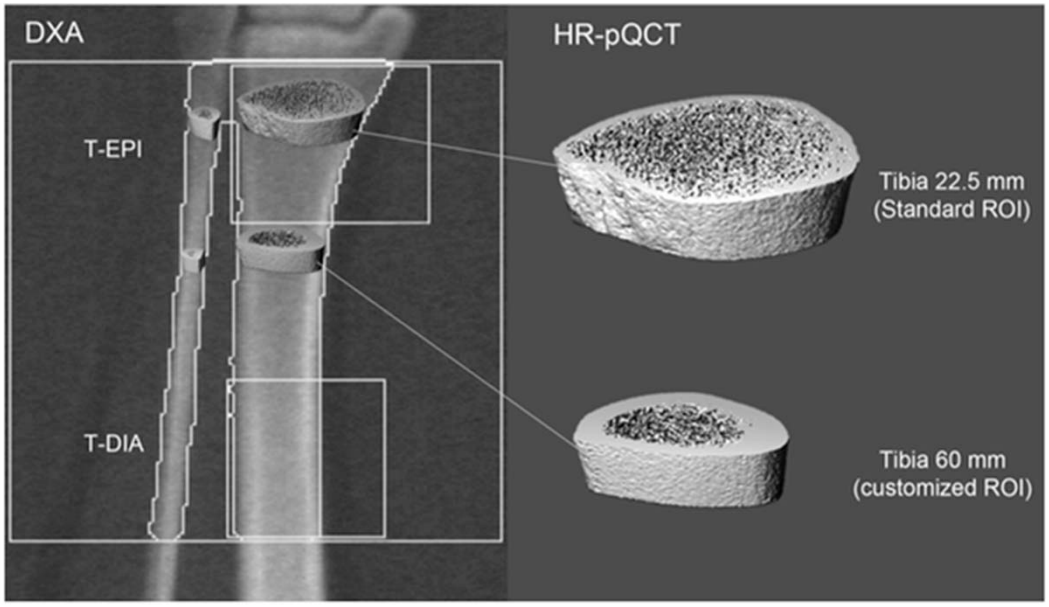
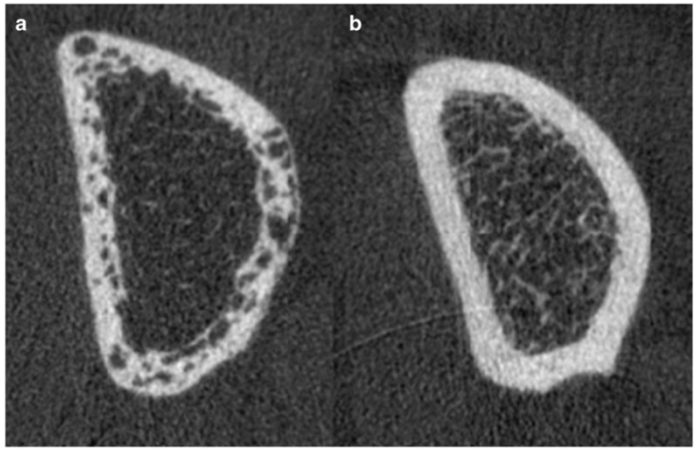


**Fig. 2** 3D render of HR-pQCT data (82 μm voxel size; in vivo) acquired from a 9.02-mm segment of human distal radius. The cortical shell has been segmented as has the internal cortical porosity (the trabecular envelop has been virtually removed)

- In vivo : **HR-pQCT**



# ΟΤΙ ΝΕΟΤΕΡΟ ΑΠΟ ΤΗΝ ΑΠΕΙΚΟΝΙΣΗ ΤΟΥ ΣΚΕΛΕΤΟΥ 2/2022-2/2023

- ΟΣΤΕΟΠΟΡΩΣΗ
- ΣΑΚΧΑΡΩΔΗΣ ΔΙΑΒΗΤΗΣ ΚΑΙ ΟΣΤΑ
- ΒΑΡΙΑΤΡΙΚΗ ΚΑΙ ΟΣΤΑ
- ΥΠΟΚΛΙΝΙΚΟΣ ΥΠΟΘΥΡΕΟΕΙΔΙΣΜΟΣ ΚΑΙ ΟΣΤΑ
- ΜΕΣΟΓΕΙΑΚΗ ΑΝΑΙΜΙΑ ΚΑΙ ΟΣΤΑ

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# Effect of Denosumab Compared With Risedronate on Bone Strength in Patients Initiating or Continuing Glucocorticoid Treatment

Piet Geusens,[1,2] Melissa SAM Bevers,[3,4,5] Bert van Rietbergen,[5,6] Osvaldo D Messina,[7] Eric Lespessailles,[8] Beatriz Oliveri,[9] Roland Chapurlat,[10] Klaus Engelke,[11,12] Arkadi Chines,[13] Shuang Huang,[13] Kenneth G Saag,[14] and Joop P van den Bergh[1,2,3,4]

**Table 1.** Baseline Characteristics

| | GC-initiating | | GC-continuing | |
|---|---|---|---|---|
| | Risedronate ($N = 24$) | Denosumab ($N = 32$) | Risedronate ($N = 30$) | Denosumab ($N = 24$) |
| Female sex | 15 (62.5) | 19 (59.4) | 28 (93.3) | 19 (79.2) |
| Premenopause | 0 (0.0) | 1 (5.3) | 0 (0.0) | 1 (5.3) |
| Postmenopause | 15 (100.0) | 18 (94.7) | 28 (100.0) | 18 (94.7) |
| Age (years) | 66.0 ± 13.1 | 68.5 ± 9.8 | 64.2 ± 8.8 | 63.6 ± 9.8 |
| Race | | | | |
| White | 24 (100.0) | 32 (100.0) | 30 (100.0) | 23 (95.8) |
| Asian | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Black or African American | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (4.2) |
| Other | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Baseline daily GC dose (mg)[a] | 18.91 ± 9.91 | 21.41 ± 15.68 | 10.32 ± 6.52 | 11.33 ± 4.95 |
| Duration of prior GC use | | | | |
| <12 months | 24 (100.0) | 32 (100.0) | 4 (13.3) | 4 (16.7) |
| ≥12 months | 0 (0.0) | 0 (0.0) | 26 (86.7) | 20 (83.3) |
| BMD *T*-score (DXA) | | | | |
| Lumbar spine | −0.77 ± 1.83[b] | −0.98 ± 1.95 | −2.60 ± 1.08 | −1.64 ± 1.80 |
| Total hip | −0.77 ± 0.79 | −1.15 ± 0.97[b] | −1.73 ± 0.86 | −1.62 ± 0.85 |

GC = glucocorticoid; BMD = bone mineral density; DXA = dual-energy X-ray absorptiometry.
Data are reported as *n* (%) or mean ± standard deviation.
[a]Dose in prednisone equivalents.
[b]Assessed in N-1 individuals.

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**Table 2.** Baseline Characteristics of HR-pQCT Measurements in Patients Initiating Glucocorticoid Therapy (GC-I) or on Long-Term Therapy (GC-C) at the Distal Radius and Tibia

| | GC-initiating | | GC-continuing | |
|---|---|---|---|---|
| Distal radius | Risedronate ($N = 24$) $n = 24$ | Denosumab ($N = 32$) $n = 29$ | Risedronate ($N = 30$) $n = 21$ | Denosumab ($N = 24$) $n = 20$ |
| μFE | | | | |
| Stiffness (kN/mm) | 77.8 ± 28.6[a] | 75.3 ± 33.4[b] | 49.7 ± 9.81[e] | 59.6 ± 23.1[f] |
| FL (kN) | 3.94 ± 1.40[a] | 3.78 ± 1.64[b] | 2.51 ± 0.50[e] | 2.98 ± 1.17[f] |
| Total bone | | | | |
| Total volume ($mm^3$) | 2842.5 ± 639.1[c] | 3060.5 ± 822.7 | 2538.6 ± 447.2[g] | 2603.6 ± 658.4 |
| Tt.BMD (mg HA/$cm^3$) | 279.2 ± 75.8 | 267.5 ± 69.5 | 213.5 ± 54.3 | 236.0 ± 70.0 |
| Cortical bone | | | | |
| Cortical volume ($mm^3$) | 522.5 ± 148.9[c] | 535.8 ± 162.7 | 416.3 ± 71.4[g] | 458.5 ± 98.3 |
| Ct.BMD (mg HA/$cm^3$) | 792.1 ± 69.4 | 790.7 ± 77.3 | 787.4 ± 48.4 | 777.5 ± 104.8 |
| Ct.Th (mm) | 0.68 ± 0.23 | 0.67 ± 0.24 | 0.53 ± 0.13 | 0.58 ± 0.23 |
| Ct.Po (%) | 2.55 ± 1.12[c] | 2.75 ± 1.24 | 2.67 ± 1.10[g] | 2.83 ± 1.34[h] |
| Trabecular bone | | | | |
| Tb.BMD (mg HA/$cm^3$) | 149.1 ± 49.7 | 140.0 ± 46.8 | 95.2 ± 42.9 | 106.6 ± 50.3 |
| Tb.BV/TV (–) | 0.12 ± 0.04 | 0.12 ± 0.04 | 0.08 ± 0.04 | 0.09 ± 0.04 |
| Tb.N ($mm^{-1}$) | 1.78 ± 0.37 | 1.71 ± 0.39 | 1.36 ± 0.44 | 1.44 ± 0.47 |
| Tb.Th (mm) | 0.07 ± 0.01 | 0.07 ± 0.01 | 0.06 ± 0.01 | 0.06 ± 0.01 |
| Tb.Sp (mm) | 0.52 ± 0.15 | 0.56 ± 0.21 | 0.79 ± 0.40 | 0.72 ± 0.30 |

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| | GC-initiating | | GC-continuing | |
|---|---|---|---|---|
| | Risedronate ($N = 24$) | Denosumab ($N = 32$) | Risedronate ($N = 30$) | Denosumab ($N = 24$) |
| Distal tibia | n = 24 | n = 29 | n = 24 | n = 21 |
| μFE | | | | |
| Stiffness (kN/mm) | 197.8 ± 56.3[d] | 194.4 ± 65.5[b] | 134.4 ± 27.6[h] | 155.9 ± 37.8[e] |
| FL (kN) | 9.99 ± 2.76[d] | 9.85 ± 3.20[b] | 6.90 ± 1.44[h] | 7.95 ± 1.83[e] |
| Total bone | | | | |
| Total volume ($mm^3$) | 6866.2 ± 1096.0[a] | 6963.0 ± 1315.9 | 6462.9 ± 1013.9 | 6345.7 ± 911.2 |
| Tt.BMD (mg HA/$cm^3$) | 259.5 ± 69.7 | 261.7 ± 55.3 | **192.8 ± 41.0** | **232.2 ± 53.4** |
| Cortical bone | | | | |
| Cortical volume ($mm^3$) | 1048.5 ± 319.8[a] | 1085.5 ± 347.2 | **803.1 ± 140.5** | **925.5 ± 140.4** |
| Ct.BMD (mg HA/$cm^3$) | 805.3 ± 61.6 | 795.1 ± 60.9 | 793.5 ± 61.2 | 800.2 ± 88.2 |
| Ct.Th (mm) | 1.03 ± 0.37 | 1.04 ± 0.35 | **0.73 ± 0.14** | **0.89 ± 0.27** |
| Ct.Po (%) | 7.16 ± 1.75[a] | 7.43 ± 2.12 | 7.40 ± 3.18 | 7.60 ± 2.88 |
| Trabecular bone | | | | |
| Tb.BMD (mg HA/$cm^3$) | 151.3 ± 42.2 | 155.1 ± 32.3 | 106.3 ± 41.4 | 127.6 ± 45.8 |
| Tb.BV/TV (–) | 0.13 ± 0.04 | 0.13 ± 0.03 | 0.09 ± 0.03 | 0.11 ± 0.04 |
| Tb.N ($mm^{-1}$) | 1.72 ± 0.38 | 1.81 ± 0.31 | 1.44 ± 0.40 | 1.63 ± 0.46 |
| Tb.Th (mm) | 0.07 ± 0.01 | 0.07 ± 0.01 | 0.06 ± 0.01 | 0.07 ± 0.01 |
| Tb.Sp (mm) | 0.53 ± 0.13 | 0.50 ± 0.10 | 0.68 ± 0.19 | 0.62 ± 0.32 |

CLINICAL TRIAL

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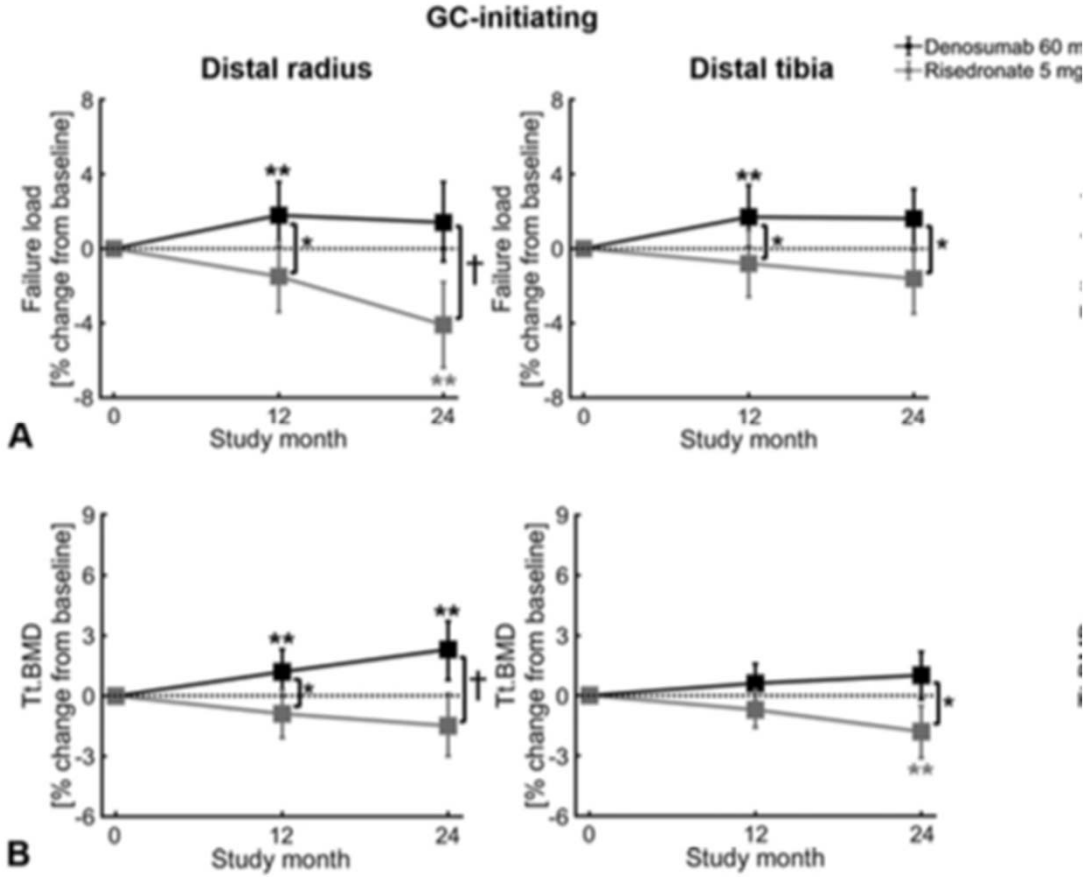

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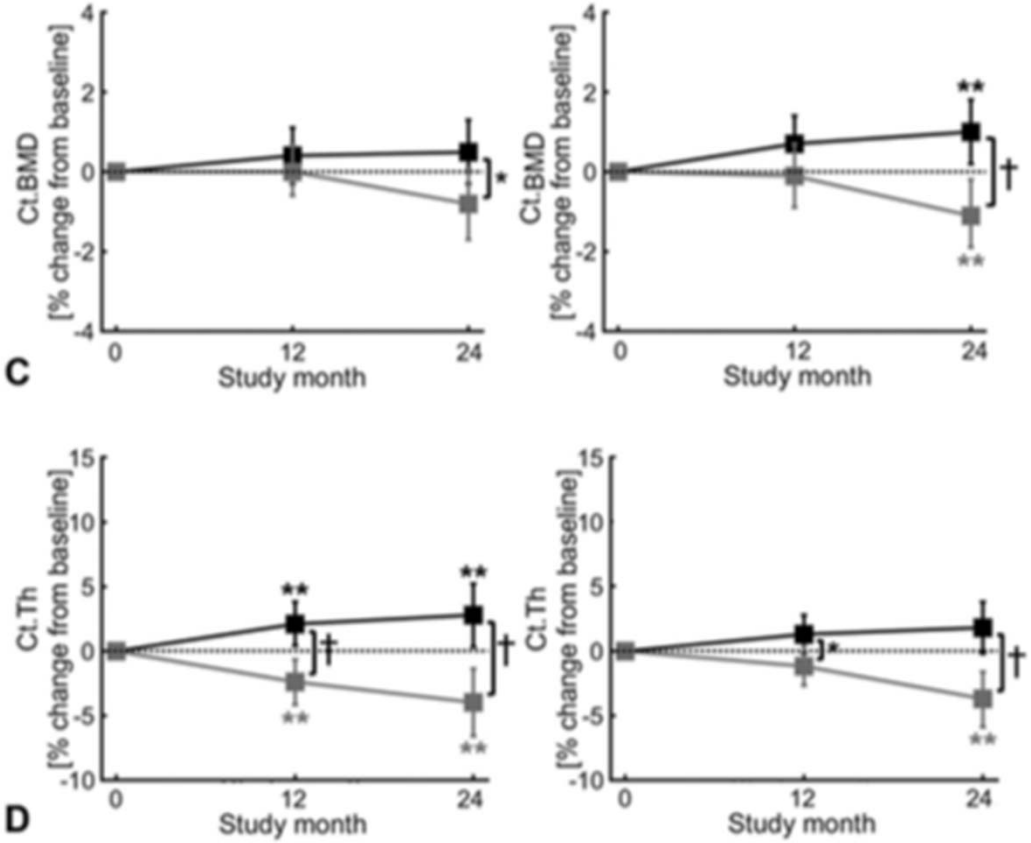

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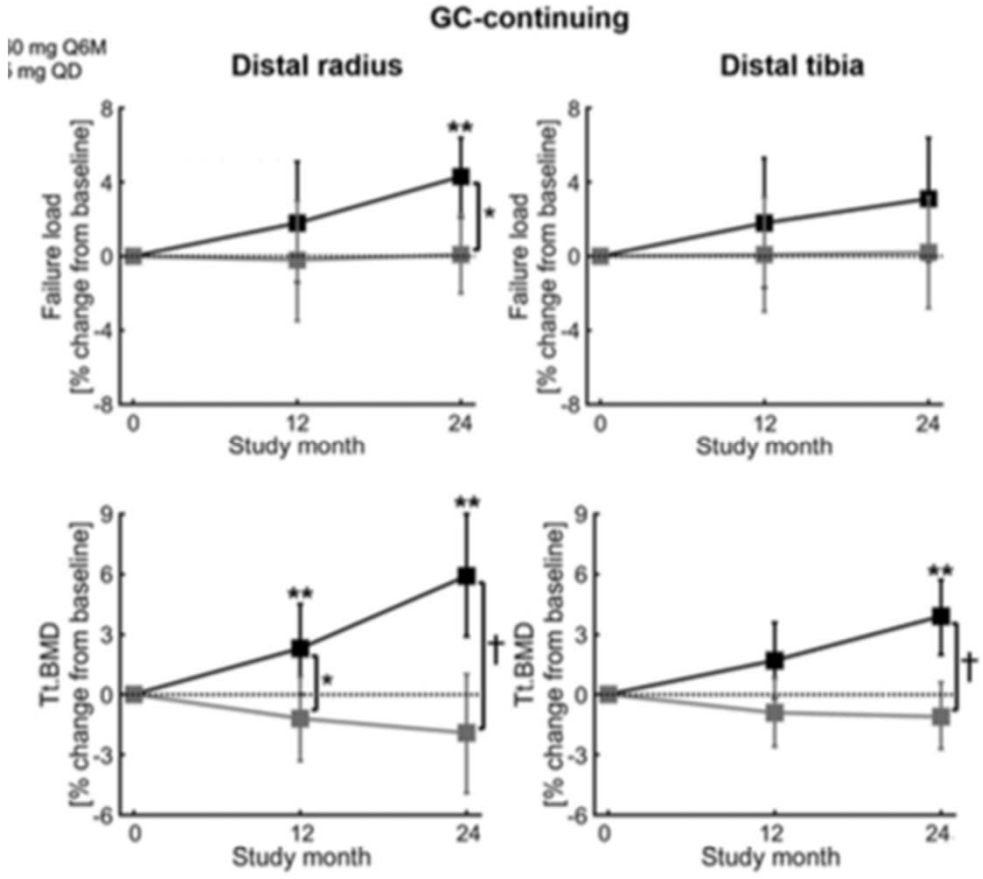

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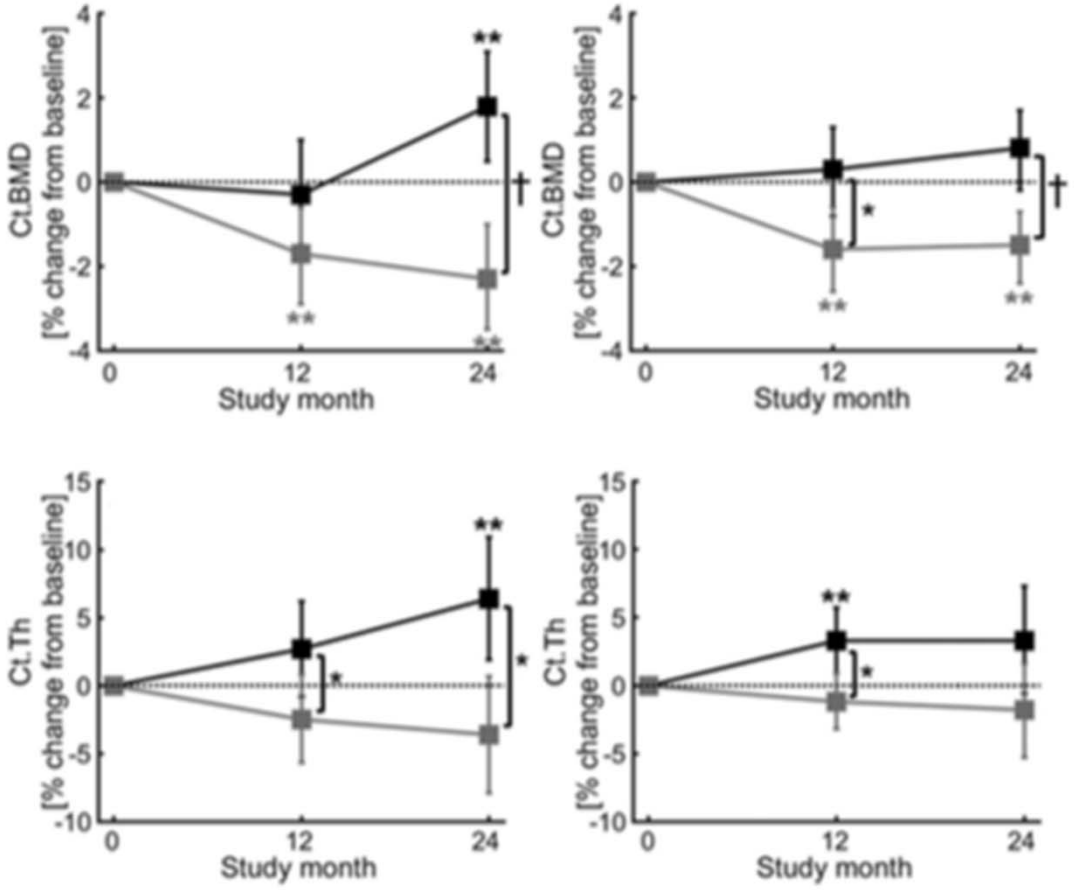
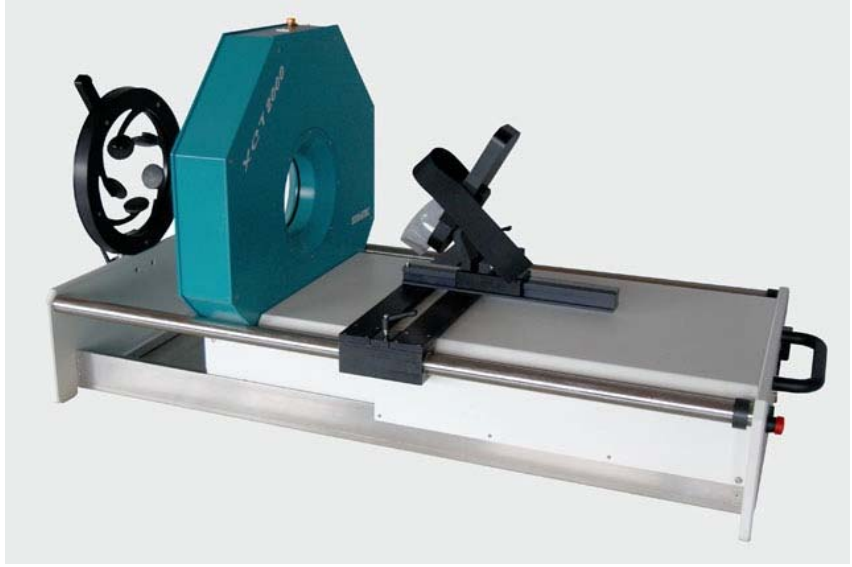
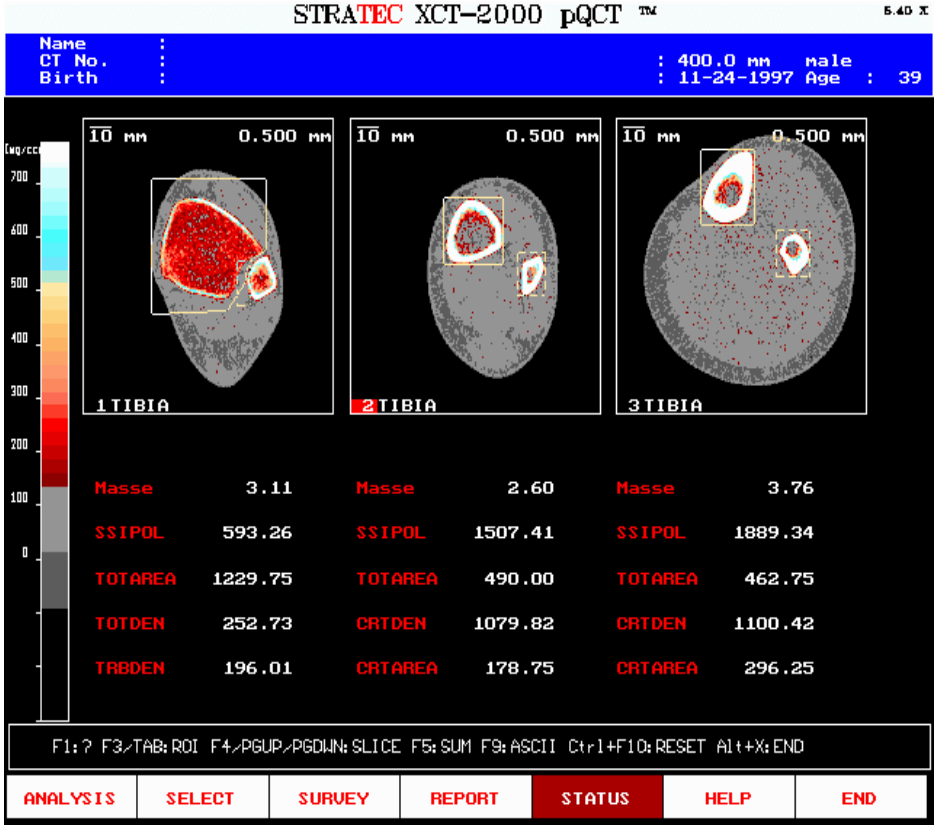


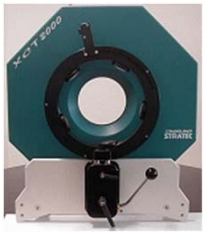
RESEARCH ARTICLE

# Greater pQCT Calf Muscle Density Is Associated with Lower Fracture Risk, Independent of FRAX, Falls and BMD: A Meta-Analysis in the Osteoporotic Fractures in Men (MrOS) Study

Nicholas C. Harvey,[1,2] Eric Orwoll,[3] Jane A. Cauley,[4] Timothy Kwok,[5] Magnus K. Karlsson,[6] Björn E. Rosengren,[6] Eva Ribom,[7] Peggy M. Cawthon,[8,9] Kristine Ensrud,[10,11] Enwu Liu,[12] Faidra Laskou,[1] Kate A. Ward,[1] Elaine M. Dennison,[1] Cyrus Cooper,[1,2,13] John A. Kanis,[12,14] Liesbeth Vandenput,[12,15] Mattias Lorentzon,[12,15] Claes Ohlsson,[15] Dan Mellström,[15] Helena Johansson,[12,15] and Eugene McCloskey[14,16]







# ΠΕΡΙΦΕΡΙΚΗ ΠΟΣΟΤΙΚΗ ΑΞΟΝΙΚΗ ΤΟΜΟΓΡΑΦΙΑ (pQCT)

**ΣΕ ΚΑΘΕ ΤΟΜΗ ΕΞΕΤΑΖΟΥΜΕ:**

-AREA MM² ( TOTAL AREA, TRABECULAR AREA, SUBCORTICAL AREA, CORTICAL AREA)

- MINERAL CONTENT, MG/CM (TOTAL CONTENT, TRABECULAR CONTENT, SUBCORTICAL CONTENT, COR TICAL CONTENT)

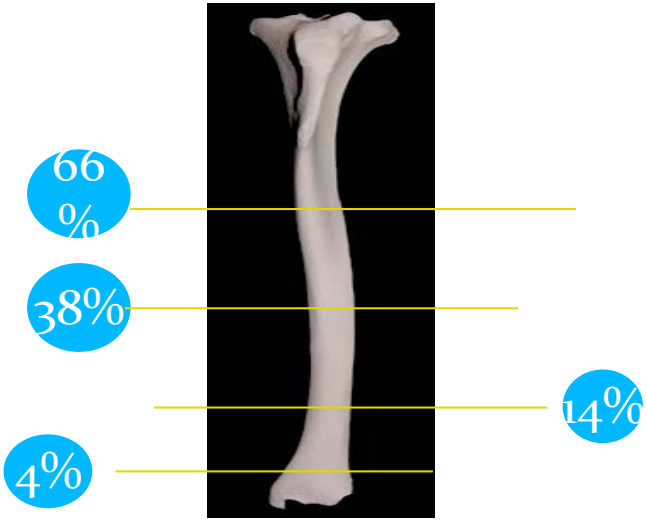
- BMD, MG/CM³ (TOTAL DENSITY, TRABECULAR DENSITY, SUBCORTICAL DENSITY, CORTICAL DENSITY)

- PERIOSTEAL / ENDOSTEAL CIRCUMFERENCE, MM² (PERI-C, ENDO-C)

- CORTICAL THICKNESS, MM

**MUSCLE AREAS: 66% (BONE TO MUSCLE RATIO) AND OR 38%**

**MUSCLE DENSITY (STRATEC XCT 3000)**



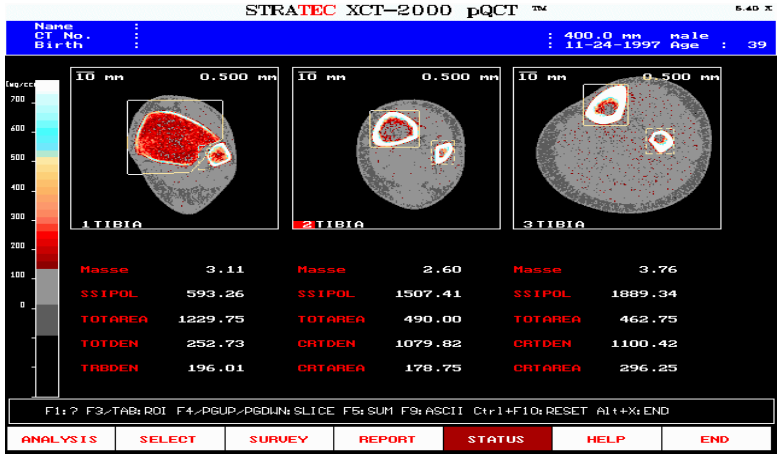



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**Table 1.** Baseline Characteristics and Fracture Outcomes of Study Participants by Country

| Characteristic | Hong Kong | Sweden | US |
|---|---|---|---|
| *n* | 1662 | 1521 | 991 |
| Person-years (total) | 13541.8 | 8057.5 | 7777.5 |
| Age (years), mean (range) | 73.9 (66.0–94.0) | 79.5 (73.1–87.7) | 77.0 (69.0–93.0) |
| BMI, mean ± SD | 23.4 ± 3.1 | 26.2 ± 3.3 | 27.8 ± 3.7 |
| Previous fracture (%) | 15.2 | 37.1 | 29.6 ($n = 989$) |
| Family history hip fracture, *n* (%) | 1382 (5.1) | 1000 (13.5) | 785 (13.4) |
| Smoker (%) | 9.8 | 7.8 ($n = 1517$) | 2.9 |
| Glucocorticoids (%) | 0.2 | 1.4 ($n = 1518$) | 2.3 |
| Rheumatoid arthritis (%) | 1.0 | 1.7 ($n = 1507$) | 5.7 |
| Excess alcohol (%) | 18.8 | 2.2 ($n = 1497$) | 7.5 ($n = 600$) |
| BMD FN *T*-score, mean ± SD | −1.41 ± 0.91 | −0.92 ± 1.02 | −0.53 ± 1.06 |
| Previous fall (%) | 17.3 | 13.2 | 23.2 |
| Muscle cross-sectional area ($cm^2$), mean ± SD | 35.4 ± 7.0 | 38.9 ± 7.4 | 75.5 ± 11.8 |
| Muscle density ($mg/cm^3$), mean ± SD | 77.0 ± 3.6 | 69.6 ± 3.7 | 70.5 ± 4.6 |
| FRAX MOF without BMD, mean ± SD | 7.9 ± 3.4 ($n = 1382$) | 15.7 ± 6.7 ($n = 976$) | 10.6 ± 5.0 ($n = 478$) |
| FRAX hip without BMD, mean ± SD | 4.3 ± 3.0 ($n = 1382$) | 9.6 ± 6.4 ($n = 976$) | 4.8 ± 4.2 ($n = 478$) |
| FRAX MOF with BMD, mean ± SD | 7.2 ± 3.7 ($n = 1382$) | 11.8 ± 6.7 ($n = 976$) | 8.2 ± 4.3 ($n = 478$) |
| FRAX hip with BMD, mean ± SD | 3.5 ± 3.1 ($n = 1382$) | 6.2 ± 6.2 ($n = 976$) | 2.8 ± 3.2 ($n = 478$) |
| FU (years), mean ± SD | 8.1 ± 2.3 | 5.3 ± 2.0 | 7.8 ± 2.2 |
| Any fx, *n* (%) | 161 (9.7) | 238 (15.6) | 137 (13.8) |
| Osteoporotic fx, *n* (%) | 125 (7.5) | 206 (13.5) | 103 (10.4) |
| MOF fx, *n* (%) | 94 (5.7) | 180 (11.8) | 68 (6.9) |
| Hip fx, *n* (%) | 47 (2.8) | 78 (5.1) | 31 (3.1) |

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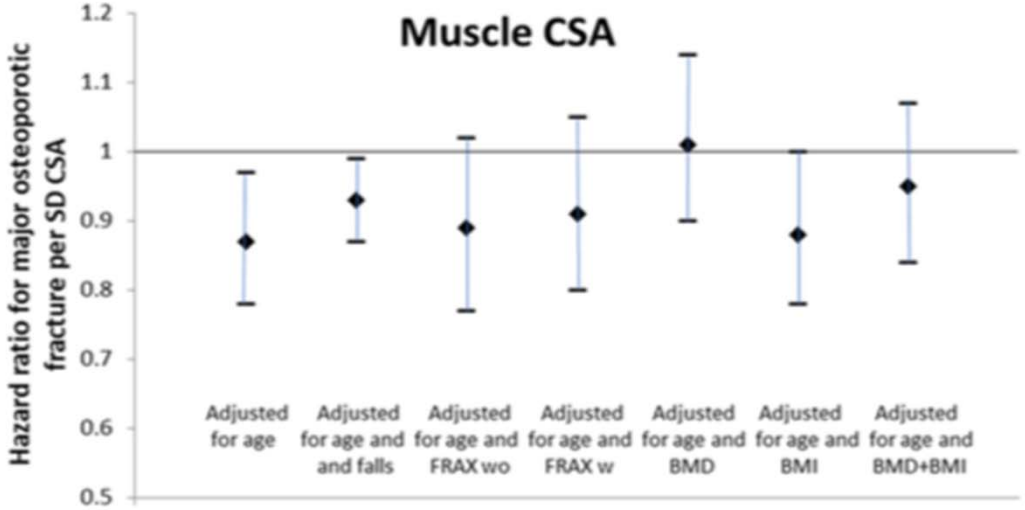


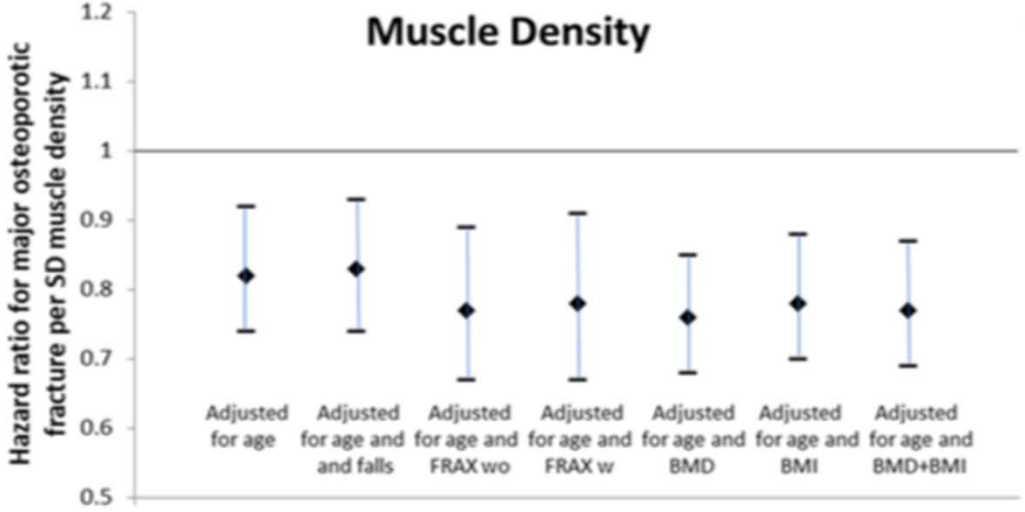

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**Table 2.** Associations between Muscle Cross-Sectional Area and Incident Fracture (US, Hong Kong, and Sweden)

| | Adjusted for | Any fx | Ost fx | MOF | Hip fx |
|---|---|---|---|---|---|
| Muscle cross-sectional area | Base: Age and follow-up time | 0.88 (0.80, 0.96) | 0.87 (0.79, 0.97) | 0.87 (0.78, 0.97) | 0.84 (0.72, 1.00) |
| | Base + FN BMD *T*-score | 0.98 (0.90, 1.08) | 0.99 (0.89, 1.10) | 1.01 (0.90, 1.14) | 1.04 (0.88, 1.24) |
| | Base + FRAX MOF wo | 0.88 (0.79, 0.99) | 0.85 (0.75, 0.96) | 0.89 (0.77, 1.02) | 0.83 (0.69, 1.01) |
| | Base + FRAX MOF w | 0.90 (0.81, 1.01) | 0.87 (0.77, 0.98) | 0.91 (0.80, 1.05) | 0.87 (0.71, 1.05) |
| | Base + prior falls | 0.88 (0.80, 0.97) | 0.87 (0.79, 0.96) | 0.93 (0.87, 0.99) | 0.85 (0.72, 1.00) |
| | Base + BMI | 0.88 (0.79, 0.97) | 0.87 (0.78, 0.98) | 0.88 (0.78, 1.00) | 0.88 (0.74, 1.06) |
| | Base + FN BMD *T*-score and BMI | 0.92 (0.84, 1.02) | 0.93 (0.83, 1.03) | 0.95 (0.84, 1.07) | 0.97 (0.81, 1.16) |
| | Base + muscle density | 0.87 (0.80, 0.95) | 0.87 (0.78, 0.96) | 0.87 (0.78, 0.97) | 0.84 (0.72, 0.99) |

Values are gradient of risk (GR) (95% CI). Models are presented adjusted for age and FU time alone and then additionally for either prior falls, FRAX MOF probability without BMD (FRAX MOF wo), FRAX MOF probability with BMD (FRAX MOF w), BMI, FN BMD *T* score or muscle density. $N = 4174$ except for +FRAX with and without BMD ($n = 2836$).

BMI = body mass index; FN = femoral neck; FU = follow-up; Fx = fracture; MOF = major osteoporotic fracture; Ost = osteoporotic; w = with; wo = without.

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## Discussion

We have demonstrated, consistent with our previous findings with DXA appendicular lean mass, that in this large population of older men across three countries, calf muscle CSA, assessed by pQCT, is only modestly predictive of incident fracture and this relationship is no longer apparent after adjustment for fn BMD. In contrast, calf muscle density, again assessed by pQCT, remained predictive of fracture outcomes after adjustment for FRAX probability, prior falls, and BMI.

**Table 3.** Associations Between Muscle Density and Incident Fracture (US, Hong Kong and Sweden)

| | Adjusted for | Any fx | Ost fx | MOF | Hip fx |
|---|---|---|---|---|---|
| Muscle density | Base: Age and follow-up time | 0.85 (0.78, 0.93) | 0.82 (0.74, 0.90) | 0.82 (0.74, 0.92) | 0.78 (0.66, 0.91) |
| | Base + FN BMD T-score | 0.80 (0.73, 0.87) | 0.76 (0.69, 0.84) | 0.76 (0.68, 0.85) | 0.69 (0.59, 0.82) |
| | Base + FRAX MOF wo | 0.79 (0.71, 0.88) | 0.78 (0.69, 0.88) | 0.77 (0.67, 0.89) | 0.73 (0.60, 0.89) |
| | Base + FRAX MOF w | 0.81 (0.72, 0.90) | 0.79 (0.70, 0.89) | 0.78 (0.67, 0.91) | 0.74 (0.61, 0.90) |
| | Base + prior falls | 0.86 (0.78, 0.94) | 0.82 (0.75, 0.91) | 0.83 (0.74, 0.93) | 0.78 (0.66, 0.92) |
| | Base + BMI | 0.82 (0.74, 0.90) | 0.78 (0.70, 0.87) | 0.78 (0.70, 0.88) | 0.72 (0.61, 0.86) |
| | Base + FN BMD T-score and BMI | 0.81 (0.74, 0.89) | 0.77 (0.70, 0.86) | 0.77 (0.69, 0.87) | 0.71 (0.60, 0.84) |
| | Base + cross sectional area | 0.85 (0.77, 0.93) | 0.81 (0.74, 0.90) | 0.82 (0.73, 0.92) | 0.77 (0.65, 0.91) |

Values are gradient of risk (GR) (95% CI). Models are presented adjusted for age and FU time alone and then additionally for either prior falls, FRAX MOF probability without BMD (FRAX MOF wo), FRAX MOF probability with BMD (FRAX MOF w), BMI, FN BMD *T*-score or muscle cross-sectional area. $N = 4174$ except for +FRAX with and without BMD ($n = 2836$).

BMI = body mass index; Fx = fracture; FN = femoral neck; FU = follow-up; MOF = major osteoporotic fracture; Ost = osteoporotic; w = with; wo = without.

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Although the majority of **sarcopenia definitions** that incorporate an estimate of muscle mass using **DXA appendicular lean mass (ALM)**, **our results have implications for the use of CT muscle measures, which can be accommodated in the most recent guidelines from the European Working Group on Sarcopenia in Older people**.[31] Consistent with our findings in MrOS, where the predictive capacity for fracture of sarcopenia definitions incorporating DXA ALM was attenuated by adjustment for femoral neck BMD,[32] **the present results suggest that a similar situation would arise using pQCT muscle CSA.** Overall then, there seems little evidential support for the use of DXA or pQCT muscle mass/area measures in the assessment of sarcopenia[28]; **muscle density might offer some extra predictive value**, **but of course would need to be balanced against the lack of pQCT scanners in most clinical departments and the high radiation dose associated with the standard CT body scanner**. An alternative strategy, particularly with the advent of machine learning image analysis, might be **opportunistic use of images obtained through routine body CT scanning**, as is being undertaken for detection of vertebral fractures.[33] **Creatine dilution** has shown some promise, and data supporting its predictive value for fracture independent of BMD

Current Osteoporosis Reports (2022) 20:398–409
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IMAGING (H ISAKSSON AND S BOYD, SECTION EDITORS)

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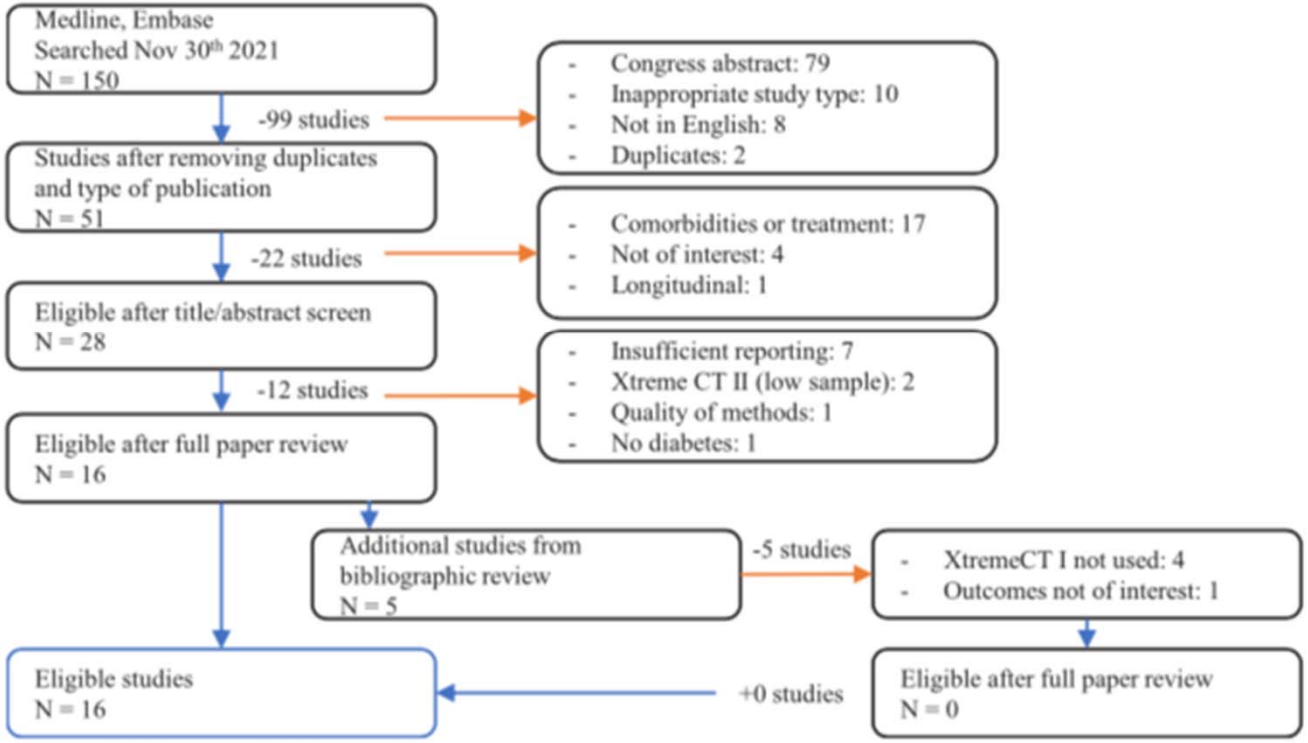

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**Table 1** Primary HR-pQCT parameters included in the meta-analysis

| Parameter (abbreviation) | Description | Units |
|---|---|---|
| Areal (Ar) bone measures | | |
| Total (Tt.Ar) | Total bone area | $mm^2$ |
| Volumetric bone mineral density (BMD) measures | | |
| Total (Tt.BMD) | Total volumetric density | mg $HA/cm^3$ |
| Cortical (Ct.BMD) | Cortical volumetric density | mg $HA/cm^3$ |
| Trabecular (Tb.BMD) | Trabecular volumetric density | mg $HA/cm^3$ |
| Cortical (Ct.) measures | | |
| Cortical thickness (Ct.Th) | Mean cortical thickness, calculated directly | mm |
| Cortical porosity (Ct.Po) | Cortical porosity, calculated using a density-based method [33] | % |
| Trabecular (Tb.) measures | | |
| Trabecular number (Tb.N) | Mean number of trabeculae per unit length | $mm^{-1}$ |
| Inhomogeneity of trabecular network (Tb.1/N.SD) | Deviation of the distance between trabeculae | mm |
| Finite element analysis (FEA) measures | | |
| Failure Load (FL) | Estimated maximum load using the Pistoia criterion [34] | N |

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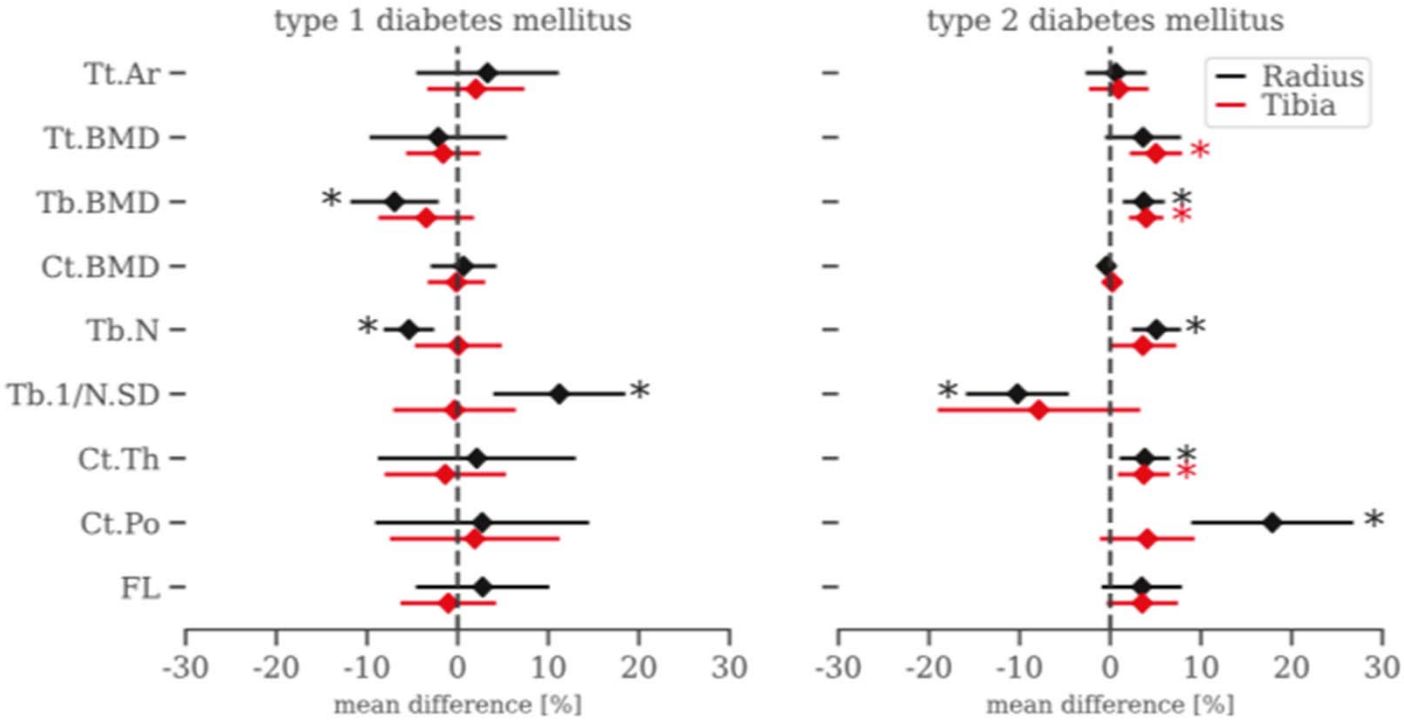

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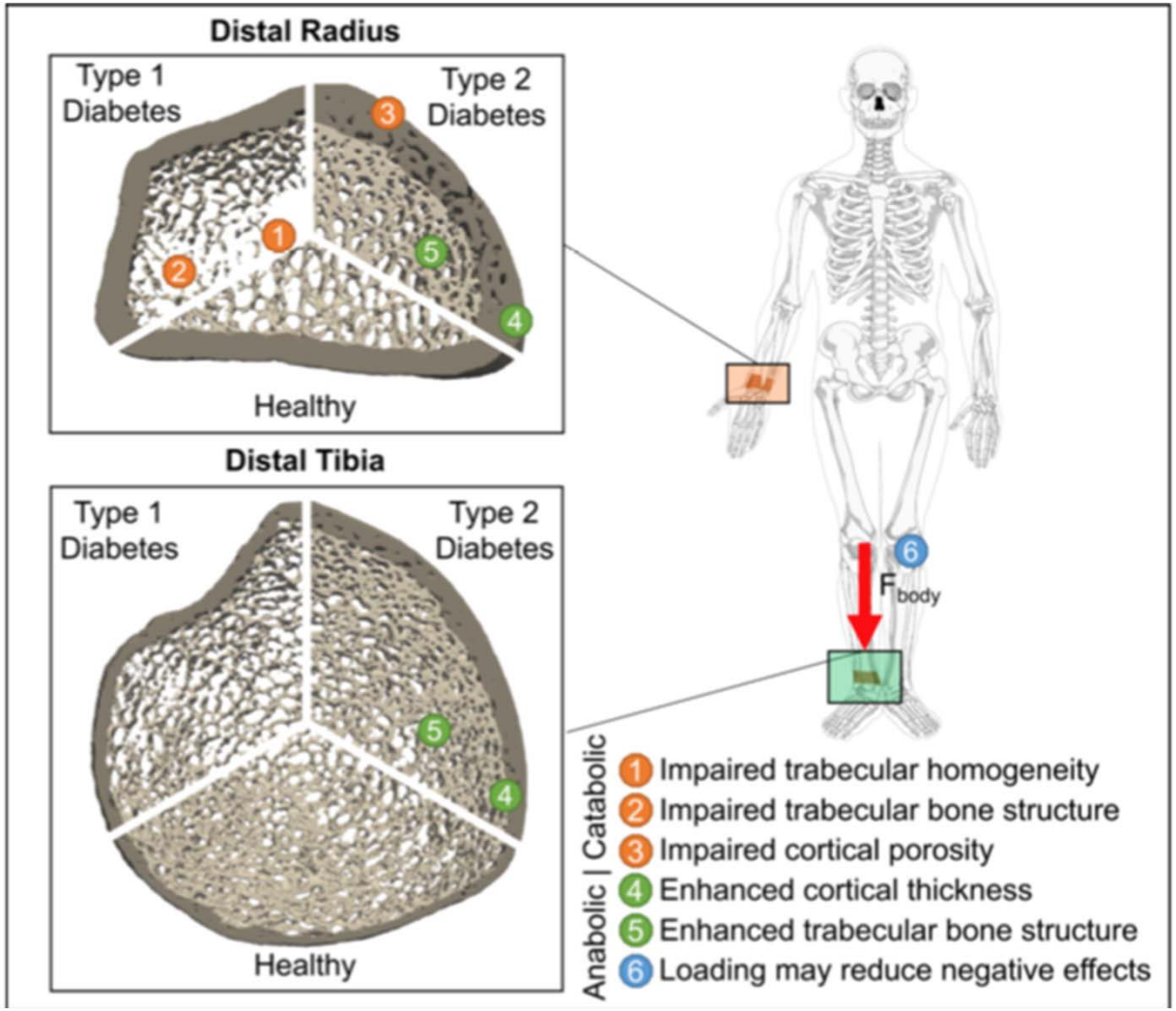

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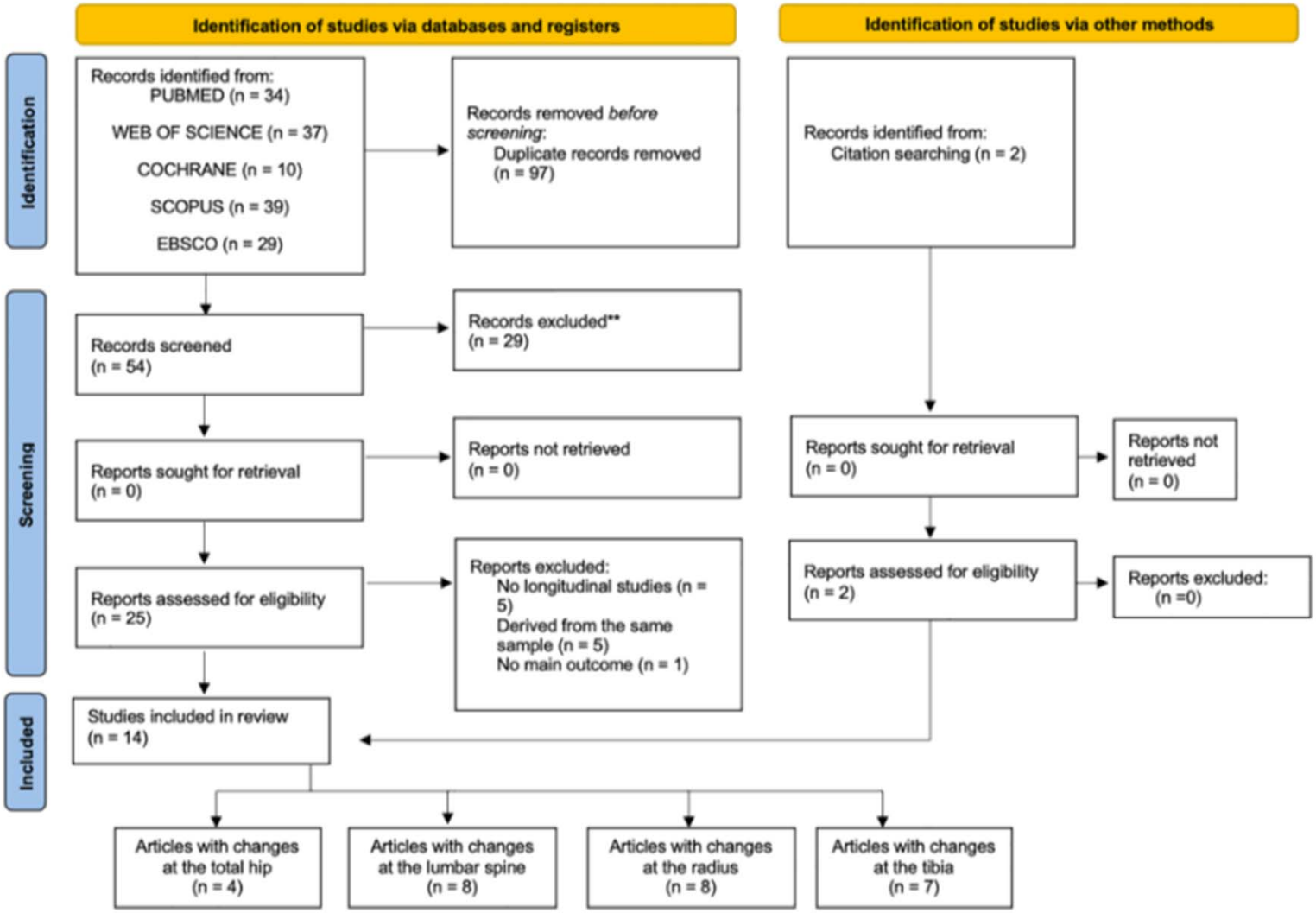

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**TABLE 1** Characteristics of the included studies

| Author and year | Sample size (n%; %♀; %postm) | Sample characteristics [mean ± SD or median (IQR)] | | Post-RYGB drugs and supplements | Outcomes | Follow-up (months) | Quality |
|---|---|---|---|---|---|---|---|
| | | Age (years) | Pre-RYGB-BMI (kg m$^{-2}$) | | | | |
| Beekman et al. 2021[44] | 14; 100%♀; 100% | 58 ± 4 | 38 ± 4 | Omeprazole and calcium carbonate/ cholecalciferol | QCT: LS | 12 | Good |
| Bredella et al. 2017[32] | 11; 90%♀; NR | 48.6 ± 8.9 | 44.1 ± 5.1 | NR | QCT: TH, LS; DXA: TH, LS | 12 | Good |
| Brzozowska et al. 2021[45] | 7; 71%♀; 60% | 51.1 ± 7.6 | 42.3 ± 7.7 | Vitamin D (25-OH > 75 nmol/L) and calcium (≥ 1000 mg/day) | QCT: LS; DXA: TH, LS, 1/3radius | 12, 24 | Good |
| Frederiksen et al. 2016[46] | 24; 58%♀; 6.7% | 41.2 ± 8.06 | 42.9 [38.7 to 47.0] | Daily intake of vitamin D (1920 IU) and calcium (800 mg) | HR-pQCT: 1/3radius, tibia; DXA: TH; LS | 6, 12 | Good |
| Hansen et al. 2020[47] | 17; 59%♀; 5.9% | 43 ± 9 | 42 ± 6 | Daily intake of vitamin D3 (38 mg:), calcium carbonate (1000–1200 mg) and multivitamin tablet | HR-pQCT: 1/3radius, tibia; DXA: TH, LS | 24, 84 | Fair |
| Ivaska et al. 2017[15] | 21; 91%♀; NR | 47.1 ± 9.9 | 48.5 | Daily intake of vitamin D3 (20 μg), calcium (1000 mg) and multivitamin tablet (including 10 μg vitamin D3) | QCT: LS | 6 | Good |
| Krez et al. 2021[29] | 17; 100%♀; 41% | 43 ± 10 | 44 ± 5 | Vitamin D (50,000 IU/week) | HR-pQCT: 1/3radius, tibia; DXA: TH, LS, 1/3 radius | 12, 24, 36,48 | Good |
| Lindeman et al. 2018[48] | 21; 81%♀; 44% | 51.1 ± 14 | 45 ± 7 | Daily intake of vitamin D (3000 IU) and calcium (1200–1500 mg) | QCT: LS; HR-pQCT: 1/3radius, tibia; DXA: TH, LS | 24, 42, 60 | Fair |
| Murai et al. 2019[49] | 24; 100%♀; 19% | 42.1 ± 8.2 | 48.5 ± 8.1 | Daily intake of vitamin D3 (3000 IU), calcium (1200–1500 mg) and protein (≥ 60 g) | HR-pQCT: 1/3radius; DXA: TH, LS, 1/3radius | 9 | Fair |
| Schafer et al. 2018[14] | 45; 79%♀; 23% | 46 ± 12 | 44 ± 7 | Intake of vitamin 25OHD to maintain ≥ 30 ng/ mL and daily intake of calcium (1200 mg) | QCT: LS; HR-pQCT: 1/3radius, tibia; DXA: TH, LS, 1/3radius | 6, 12 | Good |
| Shanbhogue et al. 2017[50] | 23; 61%♀; 4% | 42.6 ± 7.8 | 42 [38 to 47]* | NR | HR-pQCT: 1/3radius, tibia; DXA: TH, LS | 12, 24 | Good |
| Tan et al. 2015[51] | 10; 50%♀; 0% | 45.6 ± 9.1 | 36.7 ± 4.4 | Daily intake of calcium (100 mg) and ergocalciferol (50,000 IU) | QCT: TH, LS; DXA: TH, LS | 12 | Good |
| Yu et al. 2014[22] | 26; 87%♀; 33% | 47 ± 14 | 45 ± 6 | NR | QCT: TH, LS; DXA: TH, LS | 12 | Good |
| Yu et al. 2015[20] | 22; 87%♀; 33% | 47 ± 14 | 45 ± 6 | Daily intake of vitamin D (3000 IU) and calcium (1200–1500 mg) | QCT: TH, LS; HR-pQCT: 1/3radius, tibia; DXA: TH, LS | 12, 24 | Fair |

♀, women; BMI, body mass index; DXA, dual-energy X-ray absorptiometry; HR-pQCT, high resolution peripheral QCT; LS, lumbar spine; NR = not reported; postm, postmenopausal; QCT, quantitative computed tomography; RYGB, Roux-en-Y-gastric bypass; TH, total hip.
*Range.

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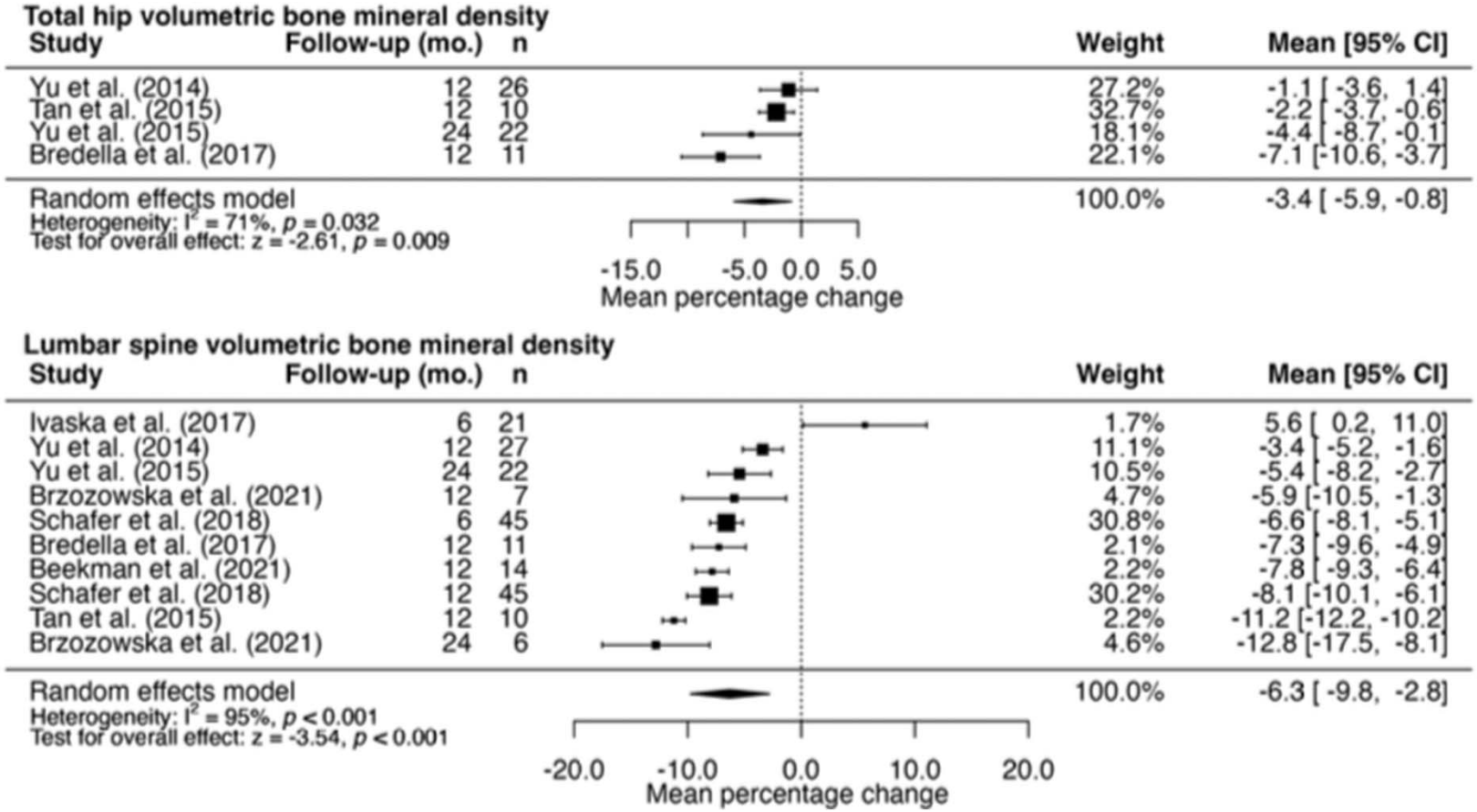

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BARIATRIC SURGERY/BODY COMPOSITION

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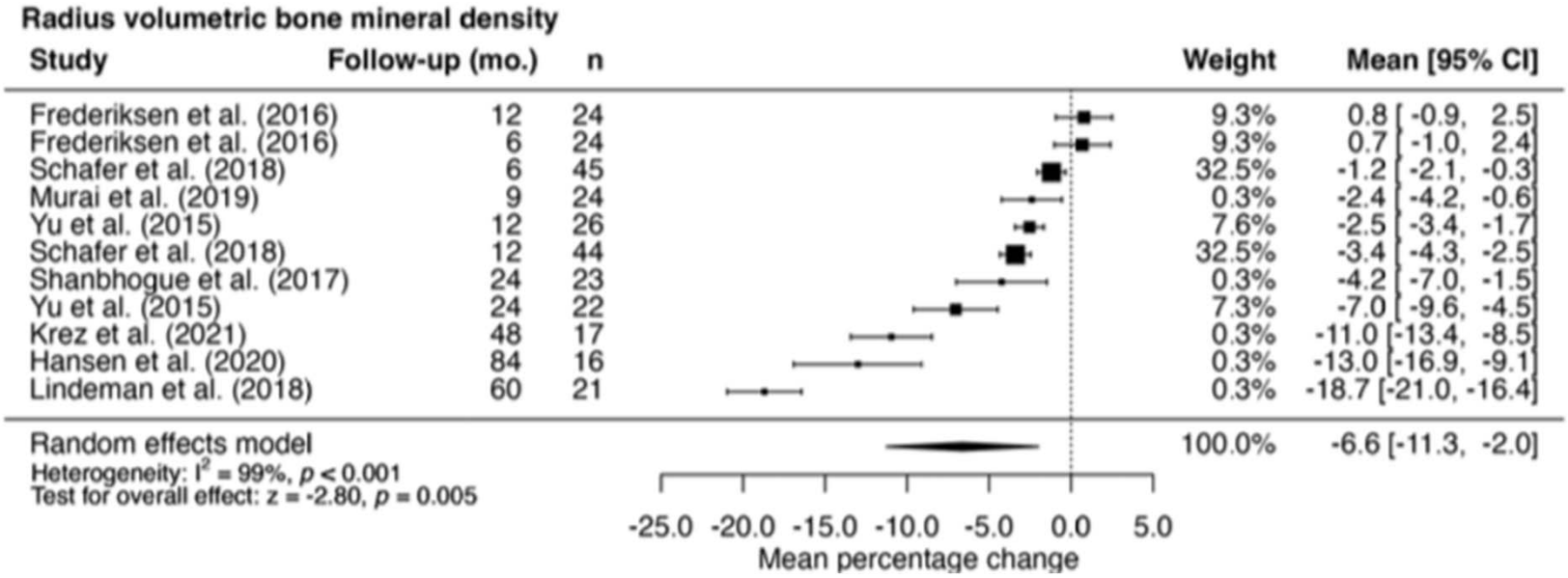

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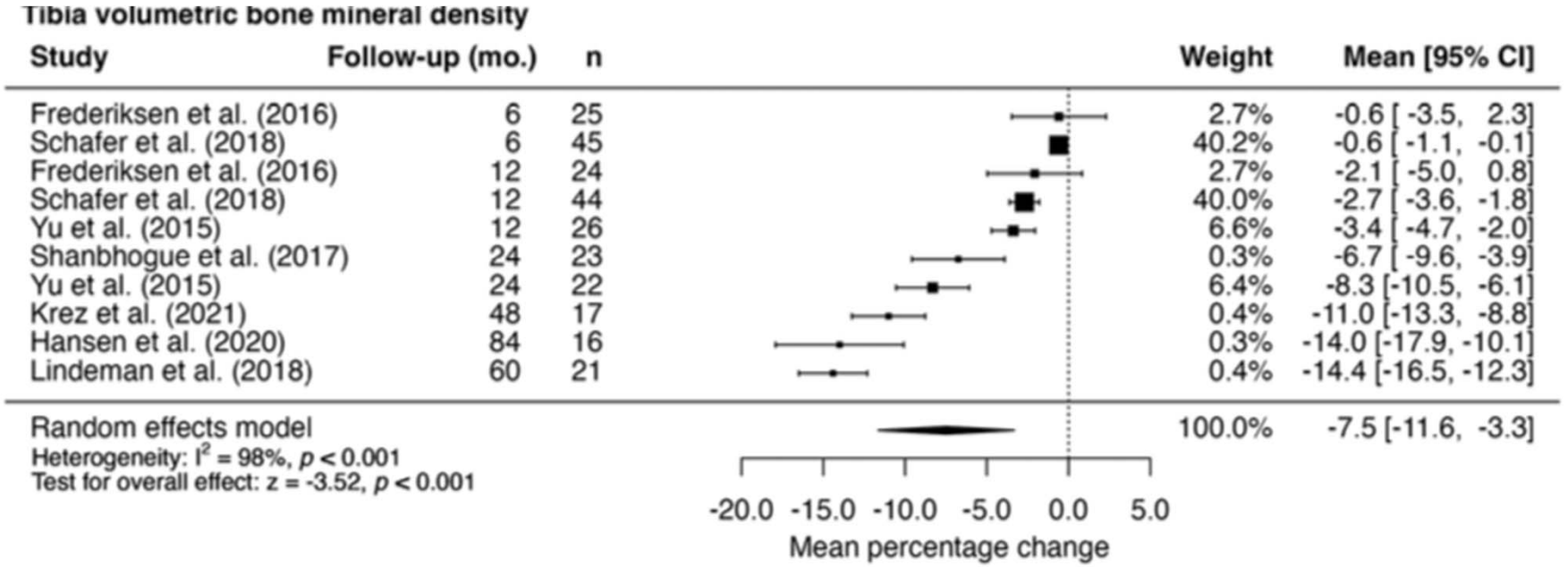

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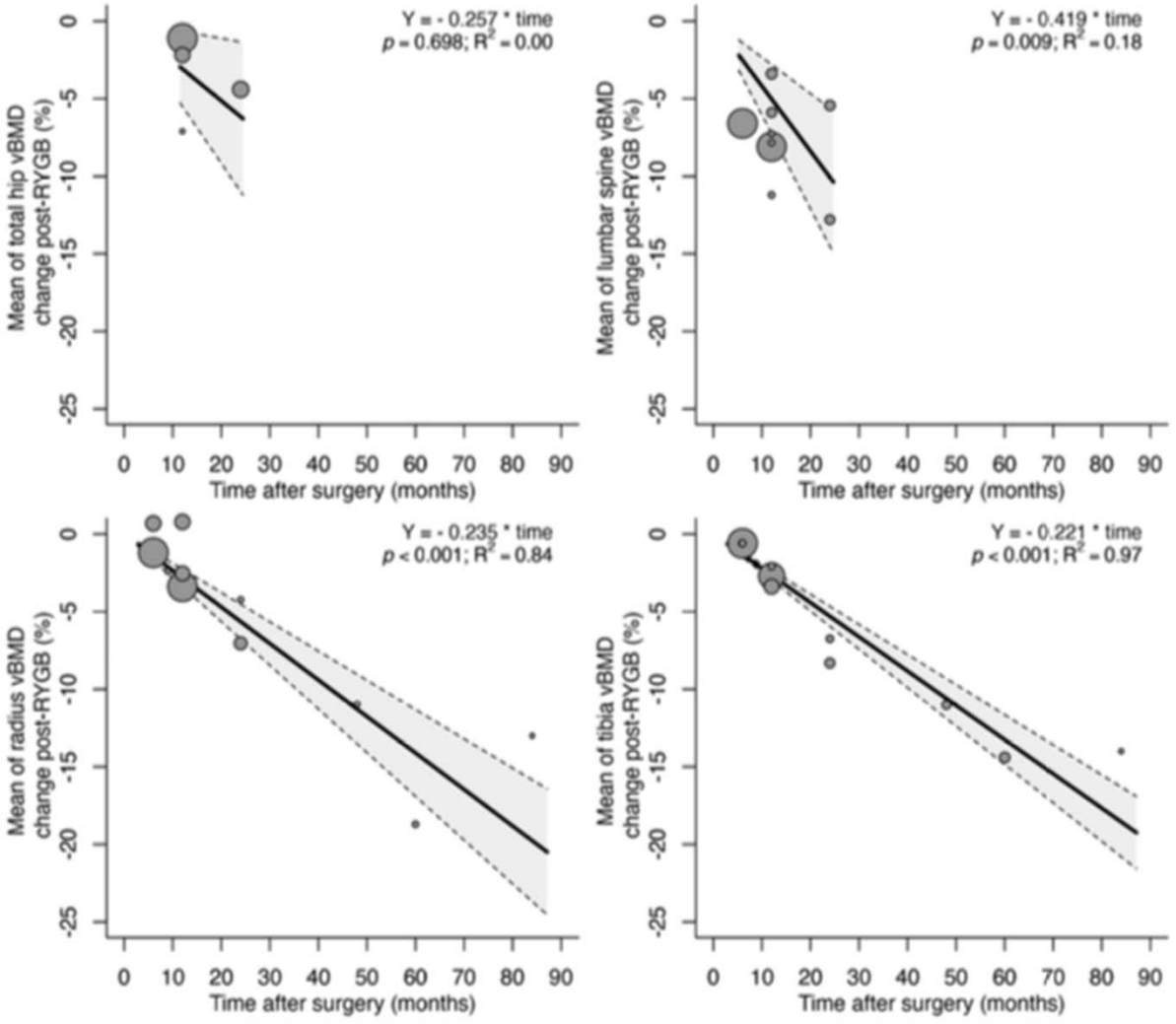

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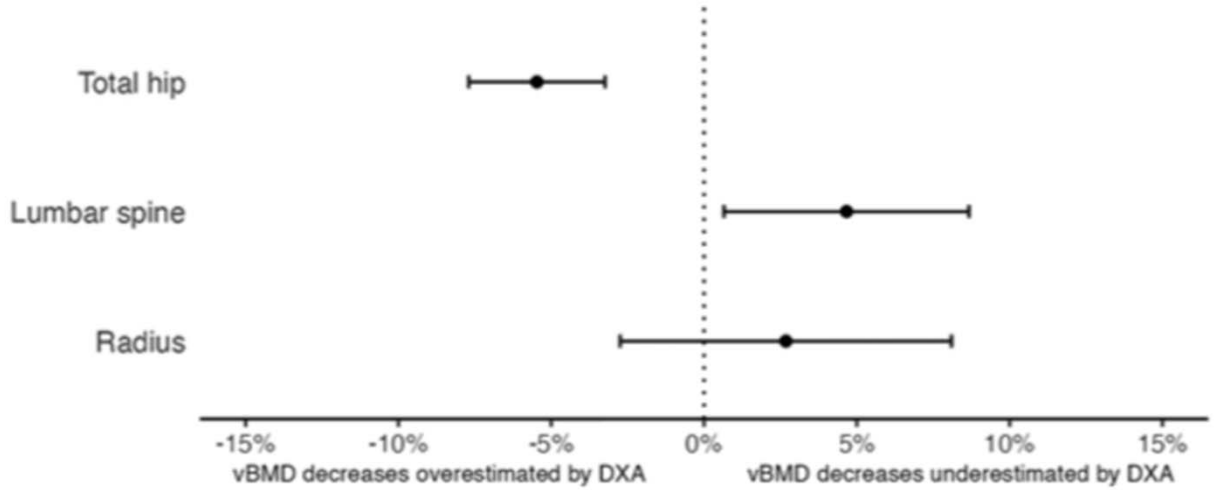


**FIGURE 6** Differences between BMD assessment techniques (DXA versus QCT and HR-pQCT)

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## 5 | CONCLUSION

The main findings of this systematic review and meta-analysis with meta-regression indicate that, after RYGB, there is a significant vBMD loss at the TH, LS, radius, and tibia. Importantly, there was an estimated annual vBMD loss of 5.0% at the LS, 2.8% at the radius, and 2.7% at the tibia during the assessed follow-up time after RYGB. Bone quality is also negatively affected by RYGB as shown by the deterioration of almost all cortical and trabecular bone parameters assessed at the radius and tibia. We also sought to determine the differences in aBMD assessed by DXA and vBMD assessed by QCT or HR-pQCT in these patients. With QCT and HR-pQCT as a reference, DXA significantly underestimated LS and overestimated TH post-BS BMD losses.

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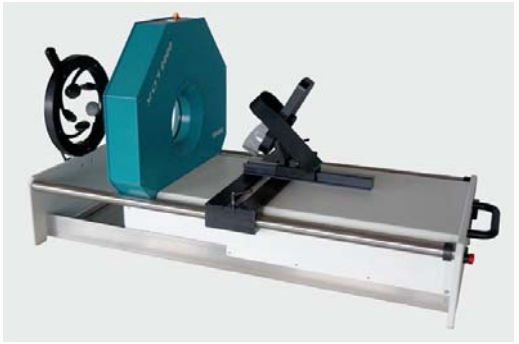

- Community-dwelling individuals aged ≥65 years with persistent SHypo were included, as detailed before [20].

- In short, persistent SHypo was diagnosed by elevated TSH levels (≥4.6 and ≤ 19.9 mIU/L) at two measurements at least 3 months apart, and FT4 levels within the assay reference range.

- Exclusion criteria were prior use of LT4, antithyroid, amiodarone or lithium treatment within 12 months before enrollment, thyroid surgery or radio-iodine, severe acute comorbidities, dementia, terminal illness or galactose intolerance [20].

- For this study, we included participants from Bern, Switzerland, of the TRUST trial who had pQCT measurements at baseline and follow-up at 1 or 2 years. The pQCT measurements were started later after funding of this nested study

-Participants were randomized 1:1 to placebo or LT4, with stratification according to country, sex and starting dose of LT4 using randomly permuted blocks.

- Treatment started with 50 µg daily (25 µg in individuals <50 kg body weight or with known coronary heart disease) of LT4 or the corresponding placebo.

- The dose was titrated according to target TSH levels ≥0.4 and <4.6 mIU/L in the LT4 arm, and a computerized mock titration was used in the placebo arm to ensure blinding.

- The intervention resulted in a significant reduction in TSH levels after 6–8 weeks and after 12 months ($p$ < 0.001), resulting in normalization in the levothyroxine group (mean 3.63 mIU/l, SD 2.11 mIU/l) compared to placebo (5.48 mIU/l, SD 2.48 mIU/l) at 12 months.

- The average dose of levothyroxine at 1 year was 50 µg

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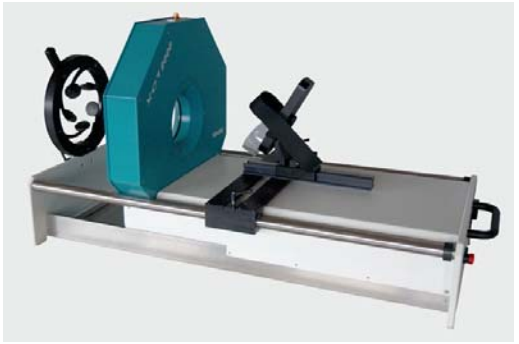

**Table 1**
Baseline characteristics of included participants, by treatment group.

| | Placebo | Levothyroxine |
|---|---|---|
| Sample size | 48 | 50 |
| Female | 19 (39.6) | 26 (52.0) |
| Age (years) | 74.0 ± 5.8 | 74.1 ± 4.9 |
| Weight (kg) | 76.5 ± 15.8 | 75.9 ± 15.2 |
| Height (cm) | 166.8 ± 8.1 | 166.4 ± 9.7 |
| BMI (kg/m$^2$) | 27.4 ± 4.8 | 27.4 ± 5.0 |
| Current smoking | 6 (12.5) | 2 (4.0) |
| Excess alcohol consumption | 2 (4.2) | 2 (4.0) |
| TSH (mIU/L) | | |
| Baseline | 6.1 ± 1.5 | 6.3 ± 2.0 |
| Median (IQR) | 5.5 (5.2–6.8) | 5.7 (5.1–6.8) |
| Range | 4.6–11.8 | 4.6–16.8 |
| Free T4 (pmol/L) | 14.3 ± 1.7 | 14.0 ± 2.1 |
| Osteoporosis history | 6 (12.0) | 6 (12.0) |
| Diabetes history | 5 (10.0) | 6 (12.0) |
| Calcium supplemented | 1 (2.0) | 2 (4.0) |
| Vitamin D treatment | 6 (12.0) | 11 (22.0) |
| Bone affecting medication | | |
| Anti-osteoporotic or HRT | 1 (2.0) | 0 (0.0) |
| HCTZ | 0 (0.0) | 0 (0.0) |
| Systemic GC | 0 (0.0) | 0 (0.0) |
| Potentially deleterious | 5 (10.0) | 1 (2.0) |
| Forearm muscle CSA (cm$^2$) | 3325 ± 934 | 2982 ± 841 |
| Lower leg muscle CSA (cm$^2$) | 7189 ± 1480 | 6555 ± 1322 |

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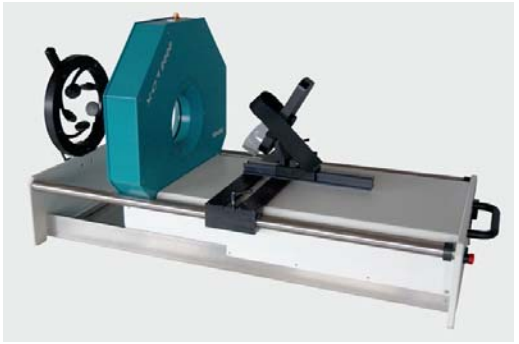

Baseline, follow-up and yearly change in pQCT measurements by groups.

| | Placebo Mean (SD) (n = 48) | LT4 Mean (SD) (n = 50) | Adjusted between-group difference (95% CI) | p-Value |
|---|---|---|---|---|
| **Radius at 4% (epiphysis)** | | | | |
| **BMC** | | | | |
| Baseline (g/cm) | 1.4 (0.4) | 1.2 (0.4) | | |
| Follow-up (g/cm) | 1.4 (0.4) | 1.2 (0.4) | | |
| Yearly change (%) | −0.2 (2.3) | −0.5 (2.5) | 0.2 (−4.3; 3.8) | 0.91 |
| **Total CSA** | | | | |
| Baseline (g/cm) | 400.2 (80.9) | 378.9 (80.2) | | |
| Follow-up (g/cm) | 403.5 (78.9) | 380.1 (80.2) | | |
| Yearly change (%) | 0.5 (4.2) | 0.3 (4.8) | 2.3 (−5.4; 10.0) | 0.56 |
| **Total BMD** | | | | |
| Baseline (g/cm) | 341.4 (61.5) | 324.9 (69.7) | | |
| Follow-up (g/cm) | 339.4 (66.1) | 322.5 (69.3) | | |
| Yearly change (%) | −0.6 (3.2) | −0.7 (3.8) | 2.5 (−8.4; 3.5) | 0.41 |
| **Trabecular BMD** | | | | |
| Baseline (g/cm) | 201.7 (43.2) | 189.1 (55.8) | | |
| Follow-up (g/cm) | 202.6 (42.6) | 189.1 (55.5) | | |
| Yearly change (%) | 0.4 (2.7) | −0.1 (3.1) | 2.7 (−2.2; 7.6) | 0.28 |
| **Radius at 66% (diaphysis)** | | | | |
| **BMC** | | | | |
| Baseline ($mm^2$) | 1.0 (0.3) | 1.0 (0.3) | | |
| Follow-up ($mm^2$) | 1.1 (0.3) | 1.0 (0.3) | | |
| Yearly change (%) | −0.6 (1.6) | −0.9 (2.1) | 0.1 (−3.1; 3.2) | 0.97 |
| **Total CSA** | | | | |
| Baseline ($mm^2$) | 160.3 (36.0) | 159.2 (41.1) | | |
| Follow-up ($mm^2$) | 160.2 (35.8) | 159.6 (41.8) | | |
| Yearly change (%) | −0.0 (2.4) | 0.2 (3.2) | −2.1 (−1.7; 5.9) | 0.27 |
| **Cortical CSA** | | | | |
| Baseline ($mg/cm^3$) | 82.6 (22.1) | 76.5 (23.2) | | |
| Follow-up ($mg/cm^3$) | 81.9 (22.1) | 75.8 (24.0) | | |
| Yearly change (%) | −1.0 (2.4) | −1.2 (3.8) | 2.5 (−6.6; 1.7) | 0.24 |
| **Cortical BMD** | | | | |
| Baseline ($mg/cm^3$) | 1102.4 (56.0) | 1097.5 (60.8) | | |
| Follow-up ($mg/cm^3$) | 1102.8 (55.5) | 1093.6 (59.9) | | |
| Yearly change (%) | 0.0 (0.7) | −0.3 (1.1) | 1.4 (−0.1; 2.9) | 0.06 |
| **Cortical thickness** | | | | |
| Baseline (mm) | 3.8 (0.7) | 3.8 (0.7) | | |
| Follow-up (mm) | 2.2 (0.5) | 2.0 (0.6) | | |
| Yearly change (%) | −1.2 (2.5) | −1.3 (3.7) | 4.2 (−9.4; 1.1) | 0.12 |

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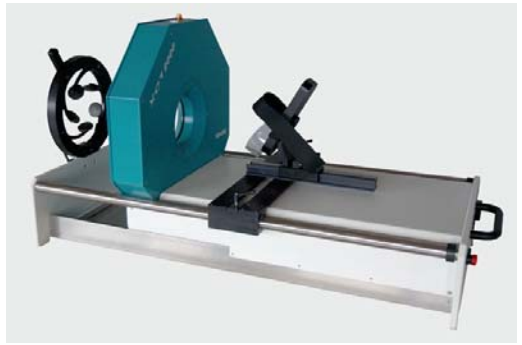

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| | | | | |
|---|---|---|---|---|
| **Tibia at 4% (epiphysis)** | | | | |
| **BMC** | | | | |
| Baseline (g/cm) | 3.5 (0.8) | 3.4 (0.9) | | |
| Follow-up (g/cm) | 3.5 (0.8) | 3.3 (0.9) | | |
| Yearly change (%) | −0.2 (1.7) | −0.9 (1.9) | 0.0 (−3.1; 3.0) | 0.99 |
| **Total CSA** | | | | |
| Baseline (g/cm) | 1210.5 (221.6) | 1204.3 (170.5) | | |
| Follow-up (g/cm) | 1201.9 (175.6) | 1203.9 (222.3) | | |
| Yearly change (%) | −0.4 (2.8) | −0.5 (2.2) | 1.1 (−3.2; 5.4) | 0.62 |
| **Total BMD** | | | | |
| Baseline (g/cm) | 292.0 (53.8) | 276.7 (49.2) | | |
| Follow-up (g/cm) | 293.0 (55.0) | 275.7 (49.9) | | |
| Yearly change (%) | 0.3 (2.1) | −0.3 (1.6) | 1.1 (−4.3; 2.0) | 0.47 |
| **Trabecular BMD** | | | | |
| Baseline (g/cm) | 221.7 (41.6) | 213.0 (44.2) | | |
| Follow-up (g/cm) | 221.8 (40.7) | 211.8 (45.3) | | |
| Yearly change (%) | 0.0 (2.1) | −0.6 (1.8) | 0.6 (−2.7; 3.9) | 0.74 |
| **Tibia at 66% (diaphysis)** | | | | |
| **BMC** | | | | |
| Baseline ($mm^2$) | 4.0 (0.8) | 3.9 (0.8) | | |
| Follow-up ($mm^2$) | 4.0 (0.8) | 3.9 (0.8) | | |
| Yearly change (%) | −0.3 (0.8) | −0.6 (0.9) | 0.2 (−1.2; 1.6) | 0.79 |
| **Total CSA** | | | | |
| Baseline ($mm^2$) | 672.0 (140.5) | 659.9 (125.2) | | |
| Follow-up ($mm^2$) | 671.2 (140.8) | 660.7 (127.7) | | |
| Yearly change (%) | −0.1 (1.6) | 0.0 (1.1) | −0.3 (−2.0; 2.6) | 0.80 |
| **Cortical CSA** | | | | |
| Baseline ($mg/cm^3$) | 300.8 (57.8) | 296.4 (62.2) | | |
| Follow-up ($mg/cm^3$) | 299.2 (58.8) | 293.4 (62.6) | | |
| Yearly change (%) | −0.5 (1.3) | −0.9 (1.6) | 1.3 (−3.8; 1.1) | 0.29 |
| **Cortical BMD** | | | | |
| Baseline ($mg/cm^3$) | 1088.0 (37.1) | 1094.2 (36.2) | | |
| Follow-up ($mg/cm^3$) | 1087.8 (38.4) | 1092.7 (36.0) | | |
| Yearly change (%) | −0.0 (0.6) | −0.1 (0.5) | 0.1 (−0.8; 1.0) | 0.82 |

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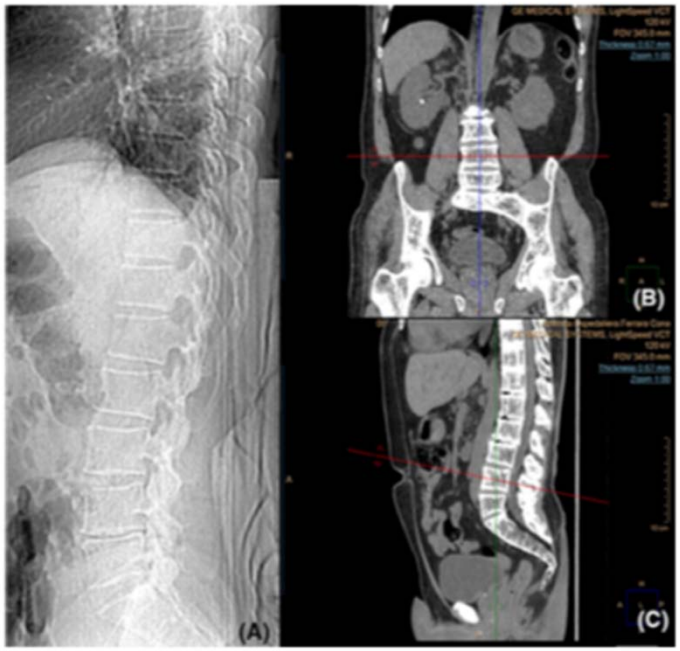


FIGURE 1 Lateral scout view is shown in (A); axes used in phantom-less QCT to detect the middle of vertebral body for BMD assessment are visible in the coronal plane (B) and sagittal plane (C), respectively

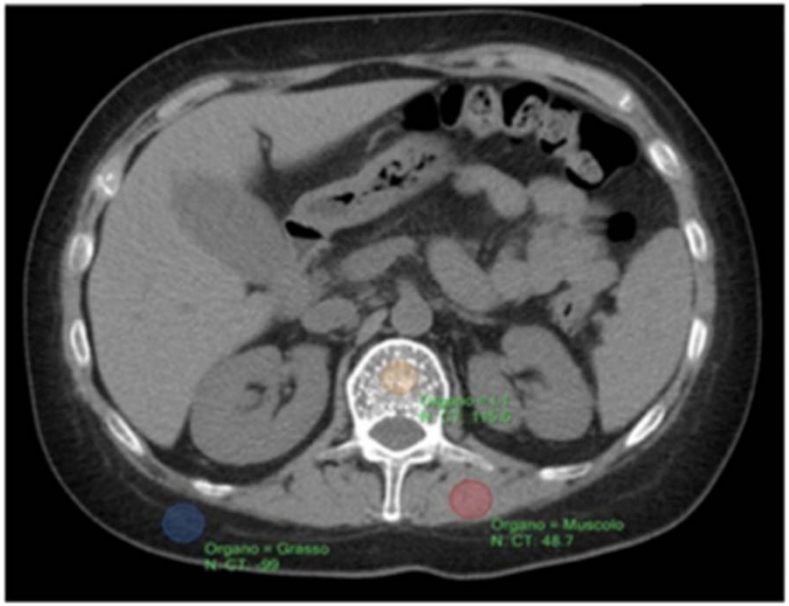


FIGURE 2 Axial CT scan in a patient with Thalassemia major. ROIs for vertebral body (orange circle), paraspinal muscle (red circle) and subcutaneous fat (blue circle) are shown with their respective CT numbers (in Hounsfield Units, HU)

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## 3 | RESULTS

We included 43 consecutive patients with β-thalassemia major (mean age ± SD: 42.6 ± 8.8 years, range 23–66 years). Among them, 28 were males (mean age ± SD: 44 ± 9; range, 23–66 years), and 15 females (mean age ± SD: 40 ± 8; range, 28–65 years). We analyzed 53 DXA and CT scans performed on the study population.

Comparison between DXA and QCT-derived T- and Z-scores.

In the study cohort, T- and Z-scores are reported in Table 1.

After comparison of lumbar spine $T_{DXA}$ with $T_{QCT}$, we found that QCT values were significantly higher (i.e., less negative) than those determined by DXA ($p = .002$) (Diagram S1).

**TABLE 1** T-score and Z-score by DXA and QCT, expressed as medians with first and third quartiles

| Parameter | Method | Median | Quartiles |
|---|---|---|---|
| Lumbar T-score | DXA | −2.90 | −4.00/−2.00 |
| | QCT | −2.30 | −3.25/−1.05 |
| Lumbar Z-score | DXA | −2.60 | −3,80/−1.75 |
| | QCT | −1.30 | −2.65/−0.25 |
| Femoral T-score | DXA | −2.60 | −3.20/−1.55 |
| Femoral Z-score | DXA | −2.30 | −2.85/−1.25 |

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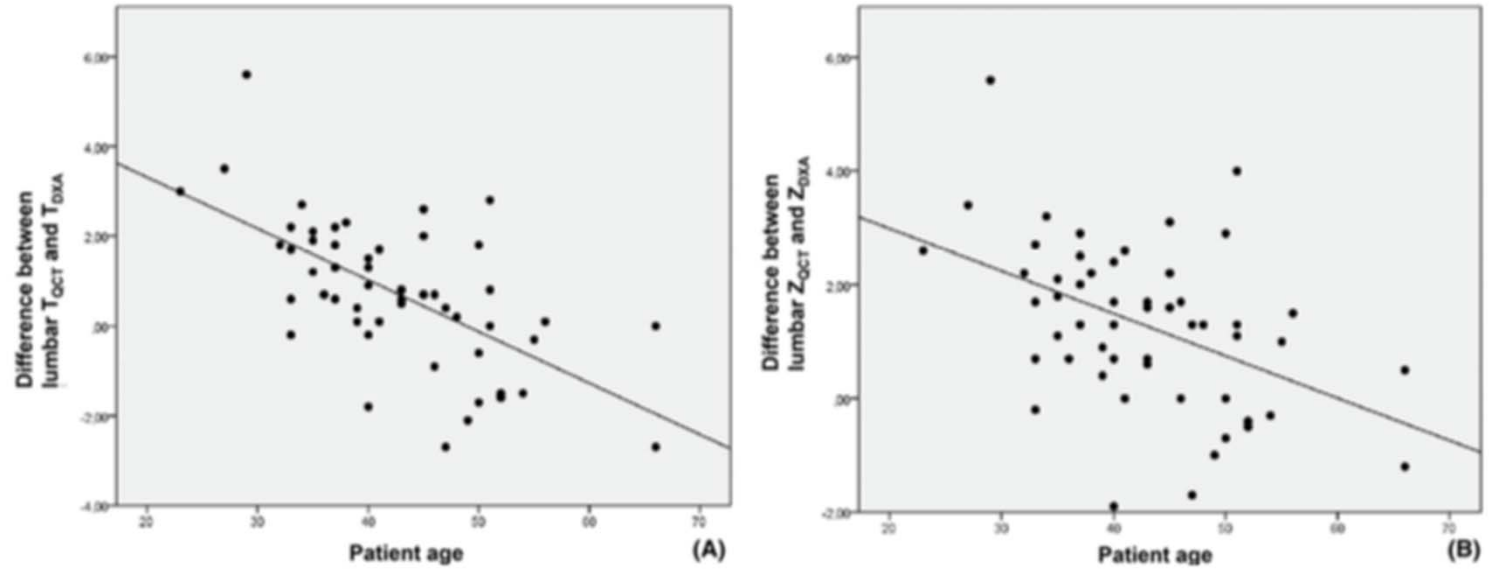


FIGURE 3 (A) Comparison between patient age (x-axis) and the difference between $T_{QCT}$ and $T_{DXA}$ at lumbar spine (y-axis) of the 53 DXA and QCT scans performed on the study population. The regression line, which represents the trend line, going down from top left to bottom right, suggests a negative correlation ($r = -0{,}626$). (B) Comparison between patient age (x-axis) and the difference between $Z_{QCT}$ and $Z_{DXA}$ at lumbar spine (y-axis) of the 53 DXA and QCT scans performed on the study population. The regression line, which represents the trend line, going down from top left to bottom right, suggests a negative correlation ($r = -0{,}454$)

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# The role of opportunistic quantitative computed tomography in the evaluation of bone disease and risk of fracture in thalassemia major

Aldo Carnevale[1] | Fabio Pellegrino[1] | Beatrice Bravi[1] | Maria Rita Gamberini[2] | Irene Gagliardi[3] | Roberto Reverberi[4] | Maria Chiara Zatelli[3] | Melchiore Giganti[1] | Maria Rosaria Ambrosio[3]

The comparison between lumbar $T_{DXA}$ and $T_{QCT}$, using, for both parameters, the ISCD classification into normal, osteopenic and osteoporotic categories (Table S2), showed the following:

- Six patients were categorized with normal $BMD_{DXA}$. Of these, four showed normal $BMD_{QCT}$, and two had osteoporotic $BMD_{QCT}$ ($p < .001$);
- 14 patients were classified with osteopenic $BMD_{DXA}$. Of these, seven had osteopenic $BMD_{QCT}$, whereas five had normal $BMD_{QCT}$ and two had osteoporotic $BMD_{QCT}$ ($p < .001$);
- The 33 patients were categorized with osteoporotic $BMD_{DXA}$. Of these, 22 had osteoporotic $BMD_{QCT}$, while 2 had normal $BMD_{QCT}$ and 9 had osteopenic $BMD_{QCT}$ ($p < .001$).

**TABLE 2** Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the best predictive variables for risk of fracture

| Parameter | Total fractures | | | |
|---|---|---|---|---|
| | Sensitivity | Specificity | PPV | NPV |
| ACR classification | 100% | 80% | 68% | 100% |
| Femoral DXA T-score | 100% | 77% | 65% | 100% |
| Lumbar QCT T-score | 100% | 23% | 62% | 100% |

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Prediction of risk of fracture.
In the study population (43 patients):

- The 12 patients had radiographic vertebral fractures (five at baseline, five during follow-up, and two at both baseline and follow-up). Among them, using the semiquantitative method by Genant, in nine patients vertebral fractures were classified as mild, in two patients as moderate and in one patient as severe;
- Five patients had rib fractures;
- One patient had a lower extremity (feet and ankles) fracture;
- No patients had femoral or upper limb fractures.



**TABLE 3** Z-scores and T-scores obtained by DXA and QCT, in patients with and without fractures, reported as medians with quartiles

| Parameter | Technique | Fracture | Median | Quartiles | *p* value |
|---|---|---|---|---|---|
| Z-score | Femoral DXA | Without | −1.50 | −2.22/−0.95 | <.001 |
| | | With | −2.90 | −3.40/−2.40 | |
| Z-score | Lumbar DXA | Without | −2.15 | −3.00/−1.05 | .016 |
| | | With | −3.00 | −4.10/−2.60 | |
| Z-score | Lumbar QCT | Without | −0.95 | −1.37/0.40 | <.001 |
| | | With | −2.70 | −3.35/−2.10 | |
| T-score | Femoral DXA | Without | −1.85 | −2.45/−1.07 | <.001 |
| | | With | −3.20 | −3.70/−2.70 | |
| T-score | Lumbar DXA | Without | −2.30 | −3.17/−1.57 | .017 |
| | | With | −3.10 | −4.20/−2.70 | |
| T-score | Lumbar QCT | Without | −1.70 | −2.60/0.32 | <.001 |
| | | With | −3.30 | −4.30/−2.75 | |

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## 5 | CONCLUSIONS

In a population of thalassaemic patients, DXA provides more negative measures than those determined by phantom-less QCT, and therefore a more pathological classification of bone mineralization. However, it seems that QCT may evaluate osteopathy better than DXA in these specific settings, since volumetric BMD would seem to have a stronger predictive role for fracture risk than DXA scans. We believe that, in the future, QCT could play a major role in conditions where interest is focused on trabecular bone deterioration, such as in β-thalassemia. Findings from this study could suggest the use of opportunistic phantom-less QCT, derived from routine abdominal CT scans, as an integrative tool in clinical practice, to obtain a comprehensive radiological evaluation of thalassaemic osteopathy using simple PACS measurement tools and a modest amount of time.

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