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Interesting image

How Auto-Segmentation Errors Turn Osteopenia into Pseudo-Osteoporosis: A Case of Tissue Area Loss and Neutral Zone Over-Subtraction

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Abstract

In dual-energy X-ray absorptiometry, accurate identification of the soft tissue area is essential for establishing baseline attenuation and ensuring precise bone mineral density measurement. This study analyzes a 75-year-old female patient who demonstrated an abrupt decline in femoral T-scores within one year. Daily quality assurance of the device and operator precision (least significant change: 0.017 g/cm^2) were within normal limits. However, due to an auto-segmentation error, the soft tissue area was lost (area = 0), and a high-density neutral zone was misclassified as the background reference, resulting in excessive subtraction of bone signal. Although the original dataset was immediately deleted due to clinical workflow demands, limiting detailed retrospective analysis, a reproduction experiment using a volunteer successfully demonstrated the same algorithmic error mechanism.

Keywords: Dual-energy X-ray Absorptiometry, Neutral Zone, Soft Tissue Area, Over-subtraction, Auto-segmentation Error, Pseudo-osteoporosis

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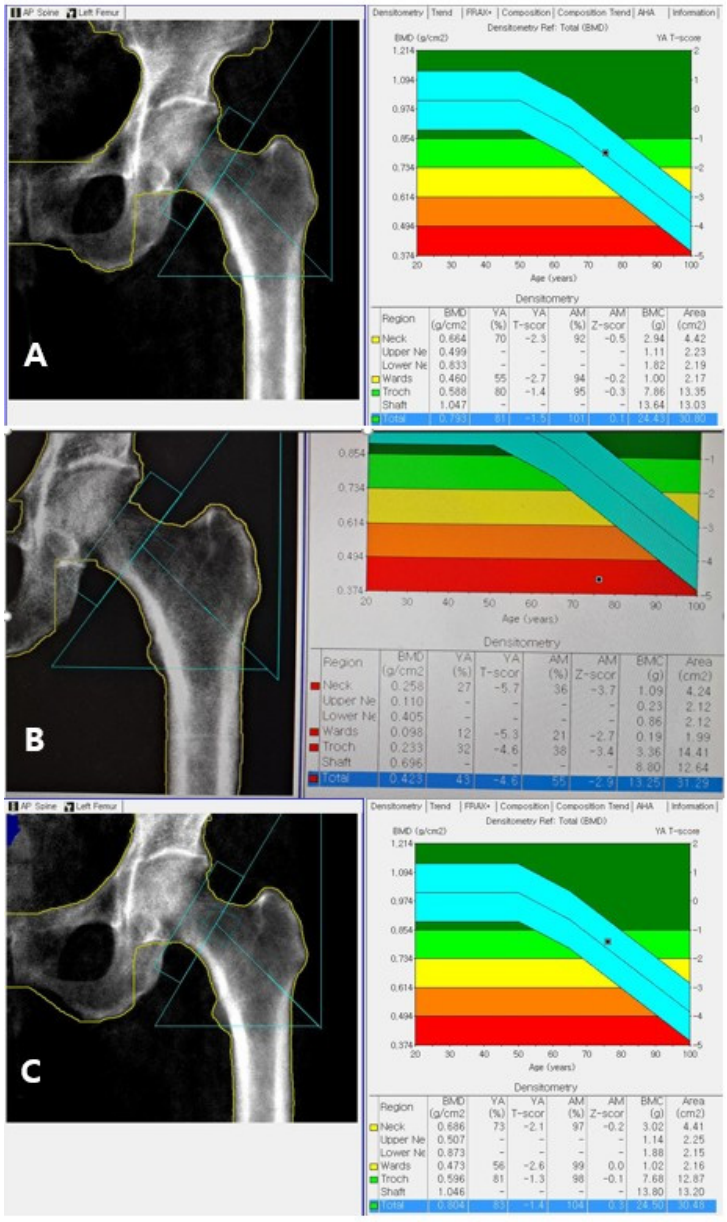

Fig. 1. The baseline scan from March 12, 2025, initially showed T-scores of -2.3 for the neck, -1.4 for the trochanter, and -1.5 for the total femur(A). A subsequent follow-up scan on March 4, 2026, exhibited a physiologically improbable and abrupt decline in all parameters, with T-scores of -5.7 for the neck, -4.6 for the trochanter, and -4.6 for the total femur(B) due to an extensive auto-segmentation error. A confirmatory re-scan performed on March 11, 2026, with manual ROI delineation successfully restored all T-scores to their respective baseline levels (T-scores of -2.1 for the neck, -1.3 for the trochanter, and -1.4 for the total femur) (C), confirming that the initial discrepancy was a technical artifact rather than a biological change.

A 75-year-old female patient underwent follow-up femoral Bone Mineral Density (BMD) measurement assessment using Dual-energy X-ray Absorptiometry (DXA) (GE, Lunar iDXA, USA). On the day of examination, daily QA using a phantom was within normal limits, and operator precision (least significant change: 0.017 g/cm²) indicated high measurement reliability. In our institution, in accordance with the recommendations of International Society for Clinical Densitometry, precision assessment (%CV and LSC) was performed approximately

five years ago using 30 volunteers, each measured twice. However, due to partial loss of the raw %CV data, direct verification of the values is currently limited. Nevertheless, the LSC derived at that time has been consistently applied in clinical practice, and the operator precision presented in this study (LSC: 0.017 g/cm²) reflects this internal quality control standard. However, the results obtained on March 4, 2026, showed an abrupt and physiologically implausible decline, with a femoral neck T-score of -5.7 and total femur T-score of -4.6 (table 1).

Table 1. serial changes in femur T-scores

date	femur neck	trochanter	total femur	remarks
2025.03.12	-2.3	-1.4	-1.5	baseline
2026.03.04	-5.7	-4.6	-4.6	auto-segmentation error
2026.03.11	-2.1	-1.3	-1.4	after manual adjustment

At that time, the clinical department requested immediate deletion of the erroneous original images to maintain consistency in reported trends, which limited further in-depth system analysis.

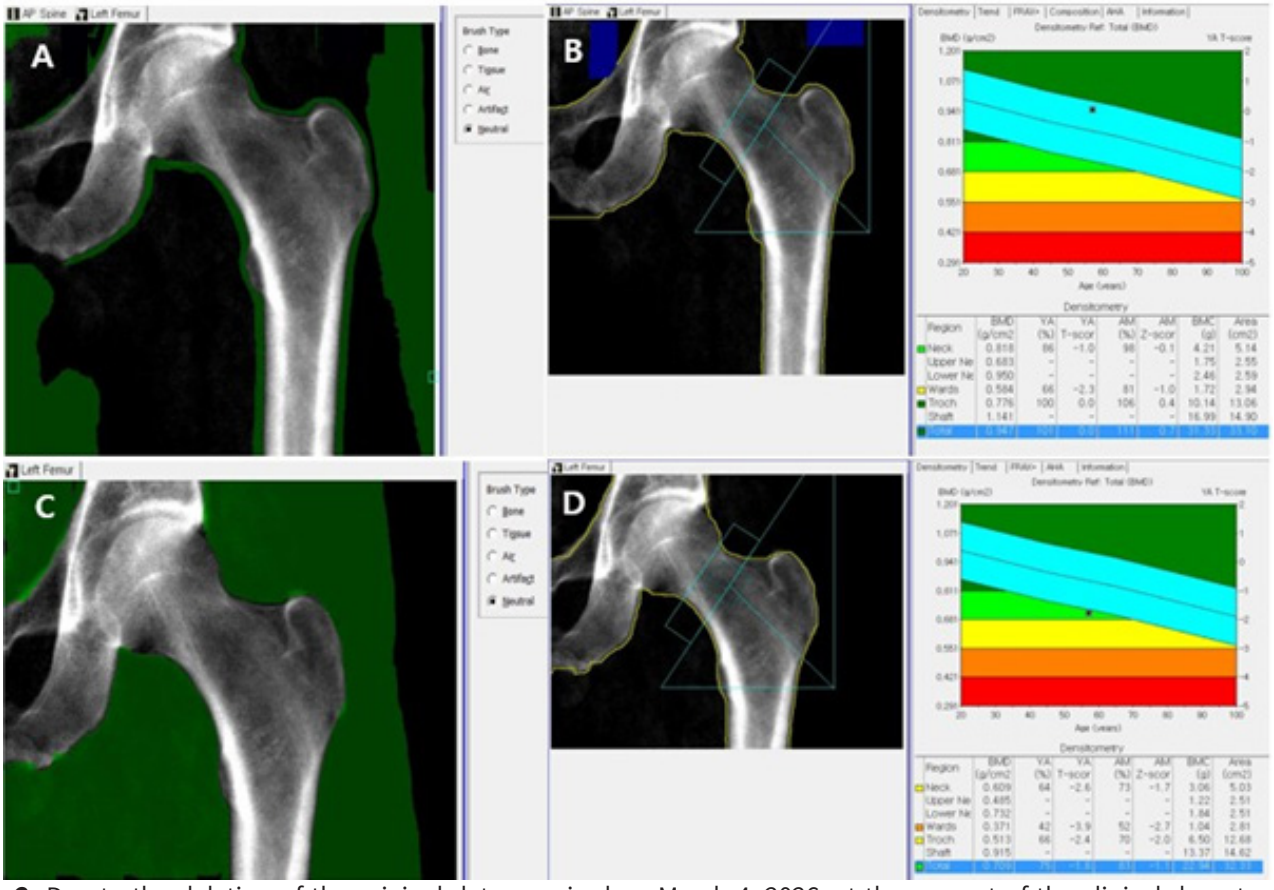

Fig. 2. Due to the deletion of the original data acquired on March 4, 2026, at the request of the clinical department, further analysis was not possible. To address this limitation, a voluntary subject was recruited, and femoral neck BMD was measured twice to assess reproducibility. In the first acquisition, automatic segmentation was used to set the neutral region (A), yielding a femoral neck T-score of −1.0 and a total femur T-score of 0.0 (B). In the second acquisition, the neutral zone was manually expanded to mimic the error condition (C), resulting in a femoral neck T-score of −2.6 and a total femur T-score of −1.8 (D), demonstrating a marked decrease in BMD similar to the original case.

To overcome the limitation caused by deletion of the original data and to clarify the error mechanism, a reproducibility test was conducted using a volunteer (57-year-old man) with two consecutive femoral scans.

1. Normal Analysis (Auto):

With standard auto-segmentation and proper neutral value assignment, results were within normal range (femoral neck -1.0, total femur 0.0).

2. Error Reproduction (Manual):

When the neutral zone was artificially expanded to invade the soft tissue area, mimicking the original case, T-scores dramatically decreased (femoral neck -2.6, total femur -1.8), reproducing the same pattern observed in the clinical case.

The DXA calculation principle separates BMD by subtracting soft tissue attenuation from total attenuation [1]. When the soft tissue area is lost (area = 0), the system incorrectly adopts a high-density neutral zone as the baseline reference. In this scenario, the equation effectively becomes:

$$\text{BMD} = \text{Bone Signal} - \text{High-Density Neutral Value}$$

This results in a mathematical cancellation of the true bone signal, leading to an "over-subtraction" artifact [2, 4]. Such technical artifacts can erroneously convert an osteopenic patient into one with severe osteoporosis, potentially leading to inappropriate clinical management. Therefore, in follow-up examinations, the use of auto-copy functions is recommended to maintain consistency with prior scans [3]. However, even with this function, any abrupt change in results must prompt verification of proper region of interest placement, particularly ensuring adequate inclusion of soft tissue area. In conclusion, when abnormal T-score fluctuations occur, strict adherence to manual analysis protocols—specifically verifying the boundaries of bone, neutral zone, and soft tissue—is essential for accurate patient management [3,4].

Conflict of Interest

The author declared no conflicts of interest.

References

1. Watts NB. Fundamentals and pitfalls of bone densitometry using dual-energy X-ray absorptiometry (DXA). Osteoporos Int. 2004;15(11):847-54. DOI: 10.1007/s00198-004-1681-7
2. Qutbi M, Soltanshahi M, Shiravand Y, Gorzi SK, Shafiei B, Asli IN. Technical and patient-related sources of error and artifacts in bone mineral densitometry using dual-energy X-ray absorptiometry: A pictorial review. Indian J Radiol Imaging. 2020;30(03):362-71. DOI: 10.4103/ijri.IJRI_495_19
3. Baim S, Leonard MB, Bianchi ML, Kalkwarf HJ, Hans DB, Langman CB, et al. Official Positions of the International Society for Clinical Densitometry and executive summary of the 2007 ISCD Pediatric Adult Position Development Conferences. J Clin Densitom. 2008;11(1):6-21. DOI: 10.1016/j.jocd.2007.12.002.
4. Tothill P, Pye DW. Errors due to non-uniform distribution of fat in dual X-ray absorptiometry of the lumbar spine. Br J Radiol. 1992;65(777):807-13. DOI: 10.1259/0007-1285-65-777-807