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SHORT SCIENTIFIC COMMUNICATION

# Intervals between bone mineral density testing with dual-energy X-ray absorptiometry scans in clinical practice

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## Abstract

**Summary** Intervals between dual-energy X-ray absorptiometry (DXA) scans were evaluated in a large cohort of typical clinical practice. Intensive DXA scanning (intervals < 23 months) decreased substantially, from 16.7% in 2006 to 6.7% in 2015.

**Introduction** Serial dual-energy X-ray absorptiometry (DXA) measurements are suggested for patients at high risk of fractures. However, little is known about how often DXA testing occurs in clinical practice.

**Methods** We examined time intervals between DXA testing for monitoring purpose at two academic medical centers in the US between 2004 and 2017. The primary outcome was the presence of testing intervals < 23 months (termed "intensive DXA testing"). A generalized linear mixed model was used to evaluate the association between selected patient-level clinical factors and intensive DXA testing.

**Results** Forty-nine thousand four hundred ninety-four DXA tests from 20,200 patients were analyzed. The mean time interval between scans was 36 ± 21 months. Only 11.1% of the repeated DXA testing met the criterion for intensive testing. The percentage of intensive DXA testing dropped from 16.7% in 2006 to 6.7% in 2015 ($p$ for trend < 0.001). After adjusting for age, gender, number of outpatient visits, and calendar year, correlates of intensive DXA testing included a baseline T-score < −2.5 at any anatomic site (OR, 4.8; 95%CI, 4.0–5.7), active use of drugs for osteoporosis (OR, 1.6; 95%CI, 1.3–1.9), and active use of glucocorticoids (OR, 1.3; 95%CI, 1.2–1.4).

**Conclusions** The predictors of intensive DXA testing suggest that this practice is used preferentially in patients with multiple risk factors and to monitor the response to pharmacotherapy. However, intensive DXA testing has become less common in real-world clinical practice over the last decade. Further studies are required to better define the optimal use of bone mineral density testing in this vulnerable population.

**Keywords** Dual-energy X-ray absorptiometry · Osteoporosis · Repeated scan · Short interval

**Electronic supplementary material** The online version of this article (https://doi.org/10.1007/s00198-019-04847-5) contains supplementary material, which is available to authorized users.

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## Introduction

Dual-energy X-ray absorptiometry (DXA) scanning is currently considered the gold standard for the measurement of bone mineral density (BMD), and a vital component in the diagnosis and monitoring of osteoporosis [1]. Serial BMD measurement can be used to determine whether treatment should be started, and to monitor the response to therapy [2]. However, the optimal time interval between BMD testing is unclear.

Current recommendations from various guidelines are contradictory regarding intervals between BMD tests [1]. For patients undergoing medical therapy for osteoporosis, the National Osteoporosis Foundation (NOF) recommends "repeating BMD monitoring 1 to 2 years after initiating therapy and every 2 years thereafter" [1]; whereas, the International Society for Clinical Densitometry (ISCD) suggests "1 year after initiation or change of therapy, with longer intervals once therapeutic effect is established" [2]. Furthermore, the American Association of Clinical Endocrinologists (AACE) gives a similar recommendation: "repeated BMD monitoring every 1 to 2 years until findings stabilize" [3]; while the American College of Physicians (ACP) recommends against any BMD monitoring during the first 5 years of treatment [4], as current evidence does not show any additional benefits for this approach. In summary, the AACE and NOF favor intensive BMD surveillance (i.e., testing intervals between 1 and 2 years), while the ACP advocates non-intensive BMD surveillance (i.e. $\geq 2$ years between tests). This controversy promotes confusion among clinicians regarding the optimal time for repeat DXA testing in practice. To date, data remain limited regarding the periodicity of DXA testing in patients receiving or not receiving medical therapy for osteoporosis.

In this study, we evaluated the time intervals between DXA scans performed for monitoring rather than screening, and examined clinical features of patients with DXA testing intervals < 23 months.

## Methods

### Study design and population

We conducted a longitudinal retrospective cohort study including 20,200 patients that had undergone DXA testing at least twice between Jan 1, 2004, and Dec 31, 2017. The cohort was identified by querying the clinical care data registry from the Partners HealthCare system. The date of the initial DXA scan was used as the index date, and patients were followed until the subsequent scan or for at least 2 years until the end of this study (supplemental S1).

Due to lack of consensus definition of what constitutes a monitoring DXA, we defined two different populations. The first population included patients who received multiple DXA tests, regardless of whether they were being treated with medications for osteoporosis. The second, on-treatment population, included patients with multiple DXA tests who were being treated with medications for osteoporosis [5]. DXA scans were excluded if they were as follows: 1) from patients under 45 years of age at the time of scan; 2) from patients who had a diagnosis of Paget's disease; or 3) performed within 60 days of the prior scan (usually a result of DXA machine malfunction or unsatisfactory reports). To ensure at least 2 years of follow-up, only initial DXA scans conducted before Dec 31, 2015, were included. The protocol for this study was approved by the Partners Human Research Committee.

### Ascertainment of outcomes and correlates

Posterior-anterior lumbar spine, total hip and femoral neck BMD were measured by DXA (QDR 4500/4500A; Hologic, Waltham, MA). DXA radiology reports were examined to corroborate scan dates and anatomic sites. The DXA scan interval was calculated as the period of time between two consecutive scans. We defined intensive DXA testing as a scan interval < 23 months [6]. Information was also collected regarding patients' demographics and comorbidities. Comorbidities were defined according to their corresponding ICD-9 or ICD-10 diagnostic codes (supplemental S2), using all data available before the index date [7]. Selected clinical factors that were thought to be possibly associated with intensive DXA testing were collected from the patients' electronic medical records, including baseline BMD, recent fragility fractures, and active use of drugs for osteoporosis, hormone replacement therapy (HRT) and glucocorticoids. Recent fragility fractures were defined as fractures related to low-impact trauma that occurred in the spine, hip, wrist, humerus, or pelvis in 12 months before the index date [8]. Drugs for osteoporosis included raloxifene, alendronate, zoledronic acid, risedronate, ibandronate, denosumab, and teriparatide. HRT included both oral estrogen and patches. Active use of glucocorticoids was defined as one or more prescriptions within 12 months before the index date. Active use of osteoporosis drugs was defined as types of osteoporosis drugs prescribed within 12 months before the index date.

### Statistical analysis

Data were reported as means or percentages of the studied population. We first calculated the intervals between two consecutive tests for all eligible DXA scans; then, plotted a histogram of the distribution. Next, we examined the trend of intensive DXA testing over time, defined as the proportion of intensive DXA testing out of the total DXA scans performed in each year. Multivariable regression models were constructed to evaluate variables associated with increased likelihood of intensive DXA testing. For the primary analysis,

a generalized linear mixed model with random effects was constructed for each patient in the larger monitoring DXA population. We constructed this model for a dichotomous endpoint by using a logit link function and the Laplace approximation method. Selected clinical factors (the baseline T-score, history of recent fragility fractures, and active use of drugs for osteoporosis and glucocorticoids) were tested in models adjusted for age, gender, number of outpatient visits, and calendar year. The same analysis was performed in the narrowly defined monitoring DXA population (patients who under treatment with medications for osteoporosis) as a sensitivity analysis. All analyses were performed using SAS software version 9.4 (SAS Institute, Inc., Cary, NC, USA).

## Result

From 2004 to 2015, there were 49,494 DXA tests among 20,200 subjects (supplement S3). Of the total population, 18,826 were women (93%) and 1374 were men (7%). Detailed baseline characteristics of the study subjects can be found in supplement S4. Baseline DXA scans showed 53.2% of the population had normal BMD, while 42.9% had osteopenia and 4.0% had osteoporosis in at least one anatomic site. The mean time interval between DXA scans was 36 ± 21 months. Very few (2%) follow-up DXA scans were performed within 12 months, 20% within 24 months, and most follow-up DXA tests (81%) were performed within 48 months. Most patients had a subsequent DXA scan within 24 to 60 months (Fig. 1a).

The overall percentage of intensive DXA testing was 11.1% between 2006 and 2015. The occurrence of intensive DXA testing decreased each year (Fig. 1b): In 2006, the percentage of intensive DXA tests was 16.7% (Fig. 1c), declining to 6.7% in 2015 ($p$ for trend < 0.001). This decreasing trend of intensive testing is consistent with the decreasing reimbursement rates reported in Medicare [9].

The odds ratios for potential correlates of intensive DXA testing were assessed in adjusted models (Table 1). A baseline DXA T-score < −2.5 at any anatomic site (OR, 4.8; 95%CI, 4.0–5.7) was the strongest correlate of intensive DXA testing. Active use of drugs for osteoporosis (2 drugs or more vs none; OR, 1.6; 95%CI, 1.3–1.9), and glucocorticoids (OR, 1.3; 95%CI, 1.2–1.4) were also correlated with intensive DXA testing. Sensitivity analysis in the on-treatment population showed similar results.

## Discussion

We examined the time intervals between DXA scans and trends regarding intensive DXA testing (< 23 months) in a large cohort of patients receiving monitoring DXA testing. The mean interval between scans was 36 months. The percentage of intensive DXA testing in the study period was 11.1%. The use of intensive DXA testing decreased substantially from 16.7% in 2006 to 6.7% in 2015, suggesting a behavior change concerning this practice.

The implementation of intensive DXA use in clinical practice has not been studied in detail in previous research. In 2014, a Medicare report indicated intensive testing (intervals < 23 months) amounted to 10.1% of all DXA scans between 2008 and 2011 in the general population [6]. Moreover, this Medicare report showed that from 2008 to 2009, intensive DXA use dropped from 12.4% to 7.6%, then slightly rose to 10.1% in 2011 [6]. Results from our study are consistent with this prior report, finding a declining proportion in intensive testing from 2006 to 2015. As our study was based on a different population (patients undergoing repeated DXAs for monitoring purpose), the percentage of intensive testing is

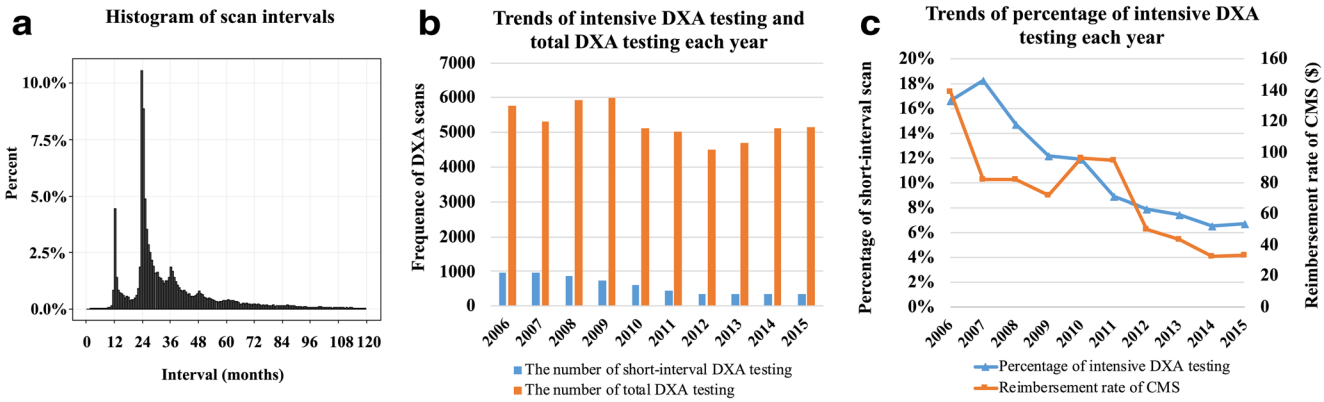


**Fig. 1** Testing intervals and trend of intensive DXA testing between 2006 and 2015. Testing intervals and trends of intensive DXA testing between 2006 and 2015. **a**. Histogram of testing intervals between 20,200 initial DXA scans and their following DXA scans. **b**. Trends of total number of DXA tests each year (orange bar), the number of intensive DXA testing in each year (blue bar). **c**. The percentage of intensive DXA testing dropped from 16.7% in 2006 to 6.7% in 2015 (blue line), this decreasing trend is consistent with the decreasing reimbursement rates reported in Medicare [9]

**Table 1** Association between selected clinical factors and intensive DXA testing

| Variables | Broad monitoring cohort* OR (95%CI) | On drug cohort # OR (95%CI) |
|---|---|---|
| Baseline BMD diagnosis | | |
| Normal | ref | ref |
| Osteopenia | 2.1 (2.0, 2.3) | 1.7 (1.5, 1.9) |
| Osteoporosis | 4.8 (4.0, 5.7) | 3.3 (2.7, 4.0) |
| Fragility fracture in 1 year | 1.1 (0.9, 1.3) | 1.1 (0.9, 1.4) |
| Active osteoporosis medication use | | |
| No | ref | ref |
| 1 drug | 1.2 (1.1, 1.3) | 1.1 (0.9, 1.2) |
| 2 or more drug | 1.6 (1.3, 1.9) | 1.4 (1.2, 1.7) |
| Active HRT use | 0.7 (0.6, 0.8) | 0.6 (0.5, 0.7) |
| Active glucocorticoid use | 1.3 (1.2, 1.4) | 1.3 (1.1, 1.4) |

Active osteoporosis drug use, active HRT use and active glucocorticoid use were defined as 1 or more prescriptions in 1 year before baseline. Active use of osteoporosis medication use were types of osteoporosis drugs used within 12 months before the index date

*Age, gender, number of outpatients visit, and DXA scan year were adjusted. Total DXA scans were used for analysis ($N = 49{,}494$)

# Age, gender, number of outpatients visit and DXA scan year were adjusted. Total DXA scans were used for analysis ($N = 28{,}701$)

OR, odds ratio

not comparable to that previously reported in general population; however, the declining trends are similar. This similarity suggests that changes in health policies have had an important impact on the patterns of intensive DXA testing in practice. Declining reimbursement rates have been linked not only to reduced overall use of DXA scans in the general population [10, 11], but also to reduced intensive DXA use for monitoring osteoporosis in both patients under pharmacotherapy or not. Besides these health policy correlates, reasons for this decreasing trend may also include shifts in physician's perspectives due to clinical guideline recommendations against frequently repeating DXA while receiving medication for osteoporosis [4, 12], as well as patients' attitudes towards this practice [4]. Whether this pattern of DXA testing equates to overuse or underuse remains controversial, further research is needed to evaluate the consequences of this shifting pattern, such as changes in fracture incidence.

Patient-level correlates of intensive DXA testing had not been assessed in previous studies. Unsurprisingly, in this study we found a baseline T-score $< -2.5$ at any anatomic sites, active use of drugs for osteoporosis and glucocorticoids were correlates of intensive DXA testing. This suggests intensive DXA testing is preferentially used in high-risk patients or to monitor the response to pharmacotherapy. This is consistent with another US study which showed women treated with medications for osteoporosis had higher rates of repeat DXA testing within 2 years [13]. In this study, we also found patients receiving 2 or more medications for osteoporosis were more likely to undergo intensive DXA. In clinical practice, most patients switched from their first drug to a second drug due to reasons, such as side effects, unsatisfactory treatment responses, fractures, or even non-adherence. After switching to a second or third drug, both patients and physicians may be more likely to more closely monitor treatment response, as evidenced by more intensive DXA testing. Notably, such intensive DXA testing is consistent with some current clinical guidelines from specialty organizations, including the AACE, ISCD, and NOF. The main argument for serial BMD testing is that it provides objective evaluation of BMD and therefore aids in the identification of treatment non-response, as well as the need for treatment reevaluation and assessment of secondary causes of osteoporosis [2, 14]. On the other hand, the new ACP guideline recommends against follow-up BMD assessment during the first 5 years of treatment, as current evidence cannot confirm that monitoring BMD while under pharmacotherapy improves outcomes. More evidence is required to clarify this issue.

Besides the factors associated with intensive DXA identified in this study, other factors that lead to rapid BMD loss should also be taken into consideration when programming follow-up DXA tests, including age, marked weight loss, treatment with gonadotropin-releasing hormone agonists, intercurrent illness, or cessation of menses within the previous 2–3 years [15], as well as problems with patients' adherence to the treatment for osteoporosis [16].

A major strength of this study is that we followed monitoring DXA utilization through 2015 and linked medical records with BMD data, which allowed us to explore the association of selected clinical factors with intensive DXA testing. Nevertheless, some limitations must be noted. First, we only evaluated DXA for monitoring purposes; DXA testing for re-screening purposes could not be defined due to lack of this

information in the electronic medical records. Second, information bias from the electronic health record-based study might affect the accuracy of estimates, such as the odds ratios of the selected clinical factors. Third, the generalizability of the results to other centers should be studied in future research.

## Conclusion

These data suggest intensive DXA testing is decreasing in clinical practice. Correlates of intensive DXA testing suggest this practice is preferentially used in patients with multiple risk factors or to monitor the response to pharmacotherapy. Whether this practice represents an overuse or underuse of the technique remains controversial. Further studies are required to better define the optimal use of BMD testing, including cost-effectiveness analyses based on current reimbursement patterns, which have changed drastically over the past decade [17].

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### Compliance with ethical standards

**Conflict of interest** None.



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