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Bone Turnover Markers as Independent Predictors of Bone Mineral Density Loss and Osteoporosis Beyond Parathyroid Hormone in Dialysis Patients: A 2-Year Prospective Multicenter Cohort Study

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Objectives : Secondary hyperparathyroidism-driven high-turnover bone disease is a major contributor to bone mineral density (BMD) loss and osteoporosis in patients with end-stage kidney disease (ESKD). However, whether bone formation marker procollagen type 1 N-terminal propeptide (P1NP) and bone resorption markers tartrate-resistant acid phosphatase 5b (TRACP-5b) and acid phosphatase (ACP) provide prognostic information independent of parathyroid hormone (PTH) remains unclear. This study aimed to evaluate whether these bone turnover markers (BTMs) independently predict BMD changes and prevalent osteoporosis beyond PTH in a dialysis cohort.
Methods : In a prospective multicenter CKD-MBD cohort of 900 dialysis patients, BTMs and intact PTH were measured at baseline and 24 months. BMD was assessed at the lumbar spine, femoral neck, and total hip. Osteoporosis was defined as T-score ≤ –2.5 at any site. Multivariable analyses were adjusted for PTH and clinical covariates.
Results : Of 452 patients with serial BMD measurements, BMD declined by 3–5% across all sites over 24 months. Baseline osteoporosis prevalence was 28.4%, and incident osteoporosis occurred in 13.0% during follow-up. Patients with PTH in the target range (150–300 pg/mL) showed the greatest femoral neck BMD loss (–7.51%), exceeding the high PTH group (–2.61%, $p<0.001$). After PTH adjustment, log(P1NP) independently predicted femoral neck and total hip BMD loss ($\beta=2.12$, $p=0.009$; $\beta=2.39$, $p=0.002$), and patients with increasing P1NP trajectories showed greater bone loss (–6.31% vs. –2.60%, $p<0.001$). TRACP-5b was independently associated with prevalent osteoporosis at any site (OR=2.92, 95% CI 1.10–8.35, $p=0.032$), and ACP with total hip osteoporosis (OR=1.48, 95% CI 1.03–2.25, $p=0.047$).
Conclusions : P1NP, TRACP-5b, and ACP independently predict BMD loss and osteoporosis beyond PTH in dialysis patients, supporting the clinical utility of BTM monitoring alongside PTH for bone health management.