

Teriparatide treatment of patients with pregnancy- and lactation-associated osteoporosis

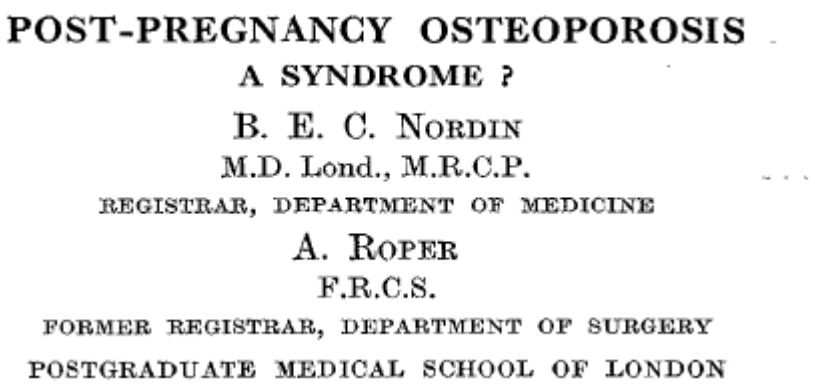
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No conflicts of interest to declare

Pregnancy- and lactation-associated osteoporosis (PLO)



POST-PREGNANCY OSTEOPOROSIS
A SYNDROME ?

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A. ROPER
F.R.C.S.
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- First described by Nordin & Roper in 1955
- **Incidence:** older estimates 4–8/million women; recent data 4.1/100,000 women (UK) to ~4.6/10,000 deliveries (Japan) **— underdiagnosed**
- **> 2/3** in the first pregnancy — third trimester or early postpartum
- Multiple low-energy **vertebral fractures** (mostly T12–L2), severe back pain, height loss
- **Up to 50%** carry relevant genetic variants (LRP5, WNT1, COL1A1/A2)

K Lampropoulou-Adamidou, G Trovas, IP Stathopoulos, NA Papaioannou. "Case report: teriparatide treatment in a case of severe pregnancy-and lactation-associated osteoporosis." *Hormones* 11.4 (2012): 495-500. Kovacs CS, Osteoporos Int 2015 · Anagnostis P, JCEM 2023 · Orhadje E, Calcif Tissue Int 2023;113:591–6 · Kasahara K, BMC Pregnancy Childbirth 2024;24:301 · Butscheidt S, Bone 2021;147:115911

Treatment of PLO remains empirical

Conservative management

- Cessation of breastfeeding
- Calcium and vitamin D
- Analgesia, spinal brace
- Spontaneous BMD recovery after weaning — but highly variable

Pharmacological treatment

- Bisphosphonates: long skeletal retention — concern for future pregnancies

Stathopoulos IP., et al. The use of bisphosphonates in women prior to or during pregnancy and lactation. Hormones 10.4 (2011): 280-291.

- Teriparatide: anabolic — PLO has low tissue-level bone remodeling

Cohen, Adi, et al. Women with pregnancy and lactation–associated osteoporosis (PLO) have low bone remodeling rates at the tissue level." *Journal of Bone and Mineral Research* 34.9 (2019): 1552-1561.

Kovacs CS, Osteoporos Int 2015 · Cohen A, JBMR 2019;34:1552 · Kyvernitakis I, Osteoporos Int 2018;29:135 · Laroche M, Osteoporos Int 2017;28:3135

Calcified Tissue International (2021) 109:554–562
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ORIGINAL RESEARCH

Teriparatide Treatment in Patients with Pregnancy- and Lactation-Associated Osteoporosis

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2021 · Teriparatide vs CaD

- TPTD n = 19 vs CaD n = 8
- LS at 12 months: **+20.9% vs +6.2%** ($p < 0.001$)
- LS at 24 months: **+32.9% vs +12.2%** ($p = 0.001$)
- PINP at 1 month predicted the 1-year LS gain

2023 · Meta-analysis

- 66 studies, n = 451 women
- TPTD vs CaD: LS **+11.5%**, FN **+5.4%**
- Only 2 comparative studies; data up to 24 months

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Meta-Analysis

ENDOCRINE SOCIETY

OXFORD

Comparative Effectiveness of Therapeutic Interventions in Pregnancy and Lactation-Associated Osteoporosis: A Systematic Review and Meta-analysis

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Aim

To compare the:

- ✓ **long-term** effect of **teriparatide (TPTD)** versus
- ✓ calcium and vitamin D supplementation alone on bone mineral density (BMD) in women with PLO.

Primary outcome

Between-group difference in % change of lumbar spine aBMD at 12 months

Secondary outcomes

Between-group differences in total hip (TH) aBMD, as well as within-group changes in LS and TH aBMD during follow-up at 1, 2, 3, 5 and 7 years.

Materials and methods

Design

- Retrospective cohort, 2010–2026
- PLO: symptomatic vertebral fractures in pregnancy or postpartum, confirmed by MRI
- Excluded: prior bisphosphonates or denosumab

Measurements

- DXA at LS and TH: baseline and 1, 2, 3, 5, 7 years
- TBS, VFA, PINP, β-CTX

Statistical Analysis

Mann–Whitney, χ^2, Wilcoxon, Friedman και Spearman, με $p<0,05$.

Group A · TPTD (n = 34)

- TPTD 20 μg/day + calcium + vitamin D
- Duration: 22 (12–24) months
- Follow-up: 51 (15–96) months

Group B · Ca + vit D (n = 13)

- Calcium + vitamin D, cessation of breastfeeding
- Age-matched; follow-up: 46 (16–82) months

Patient flowchart

Baseline	Group A · TPTD: **34**		Group B · Ca + vit D: **13**
Year 1	**31** on TPTD (−3 L)		**13** (−1 P)
Year 2	**26** completed TPTD (−3 O, −2 L, −2 P)		**12** (−1 L, −1 P)
After TPTD	**11** no subsequent treatment	**15** BPs (n=12) or Dmab (n=3)	
Year 3	**8** (−1 O, −2 L, −1 P)	**13** (−1 O, −1 L, −1 P)	**8** (−4 L, −2 P)
Year 4	**5** (−1 O, −2 L, −1 P)	**12** (−1 O)	—
Year 5	**5** (−1 P)	**8** (−1 O, −3 L)	**4** (−1 O, −3 L)
Year 6	**2** (−2 O, −1 L)	**5** (−3 O)	—
Year 7	**2**	**4** (−1 L)	**3** (−1 O)
Year 8	**2** ongoing	**4**	—
Year 9		**2** ongoing (−2 L)	**2** (−1 O)

O: follow-up ongoing · L: lost to follow-up · P: another pregnancy · BPs: bisphosphonates · Dmab: denosumab

Baseline characteristics

	Group A	Group B	p
Age (years)	36.2 ± 5.4	35 ± 4.8	0.452
Weight (kg)	59 ± 9.7	61 ± 5.1	0.210
Height (cm)	158 ± 26	164 ± 5.3	0.606
BMI (kg/m²)	22.3 ± 3.3	23 ± 2.4	0.217
1st / 2nd / 3rd pregnancy, n (%)	28 (82) / 5 (15) / 1 (3)	9 (69) / 3 (23) / 1 (8)	0.579
Pre- / postpartum, n (%)	9 (26) / 25 (74)	5 (38) / 8 (62)	0.421
Lactation (months)	3.9 ± 5.3	6 ± 7.5	0.678
IVF, n (%)	4 (12)	1 (8)	0.887

	Group A	Group B	p
VFs, median (range)	4 (2–13)	3 (1–9)	**0.012**
Height loss (cm)	5.1 ± 2.7	5 ± 2	0.677
Secondary causes, n (%)	6 (18)	3 (23)	0.672
Smoking, n (%)	4 (12)	0 (0)	0.206
Family history of OP, n (%)	15 (44)	3 (23)	0.184
LMWH, n (%)	20 (59)	3 (23)	0.096
Pain to diagnosis (months)	2 ± 2	6 ± 9.7	0.098

Group A: TPTD (n=34) · Group B: Ca + vit D (n=13) · mean ± SD, median (range) or n (%) · VFs: vertebral fractures · LMWH: low-molecular-weight heparin

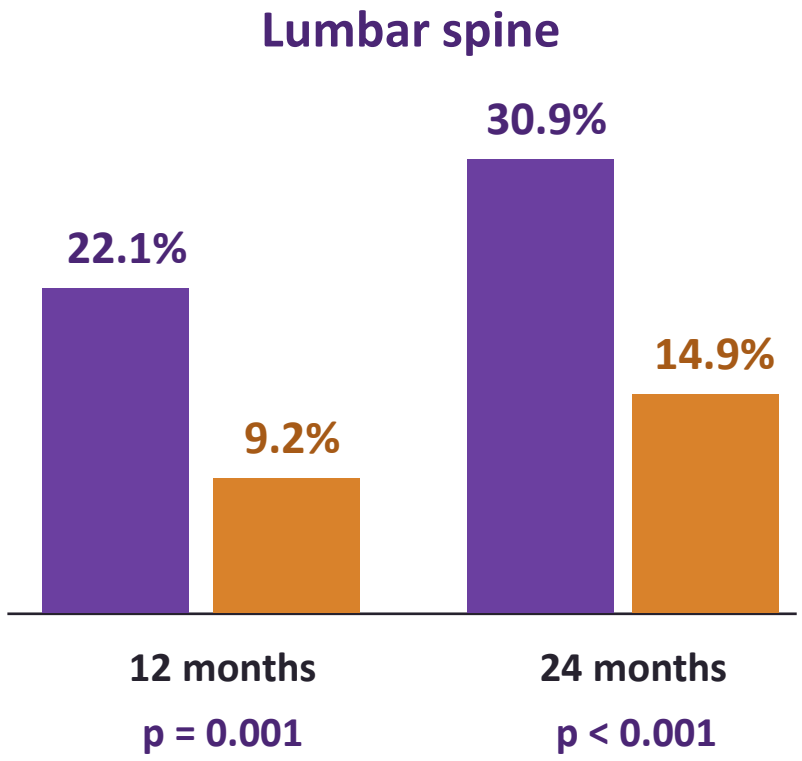
Baseline bone density and biochemistry

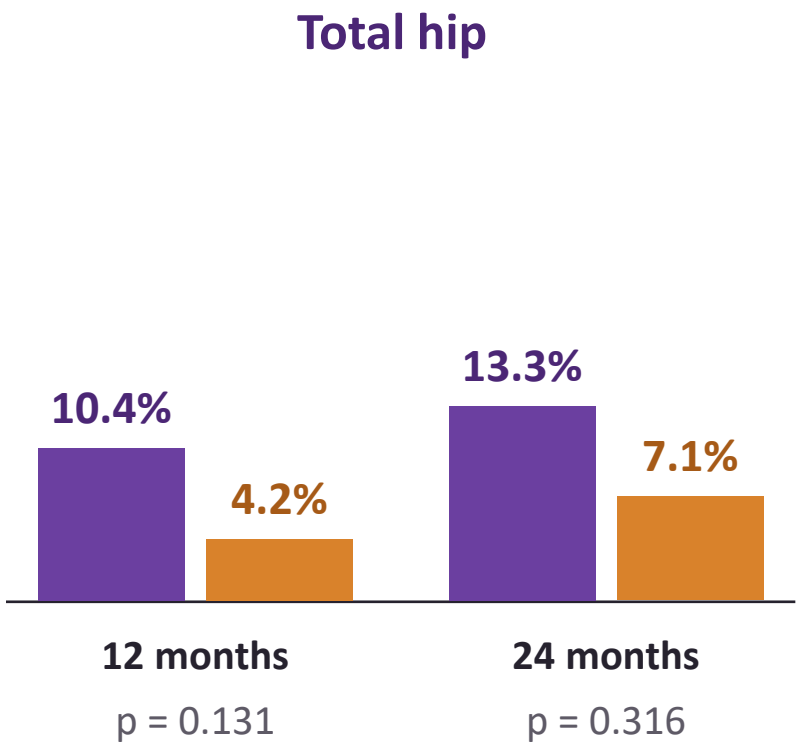
	Group A	Group B	p
LS aBMD (g/cm²)	0.777 ± 0.13	0.798 ± 0.11	0.631
LS Z-score	−3.2 ± 1.0	−2.9 ± 0.95	0.171
TH aBMD (g/cm²)	0.692 ± 0.11	0.745 ± 0.06	0.414
TH Z-score	−2.5 ± 0.89	−2.1 ± 0.6	0.259
TBS	1.224 ± 0.11 (n=14)	1.34 ± 0.01 (n=2)	0.160

	Group A	Group B	p	RR
Ca (mg/dL)	9.6 ± 0.35	9.4 ± 0.3	0.076	8.4–10.2
P (mg/dL)	4 ± 0.55	3.7 ± 0.67	0.265	2.5–4.7
Creatinine (mg/dL)	0.65 ± 0.06	0.67 ± 0.05	0.353	0.6–1.1
ALP (IU/L)	95.6 ± 44.1	65 ± 5.66	0.167	40–150
25(OH)D (µg/L)	28 ± 13.7	26.2 ± 12.8	0.830	20–50
PTH (ng/L)	27.4 ± 16	32.3 ± 8.25	0.065	10–65
NmidOC (µg/L)	38.7 ± 20.2	31.9 ± 8.4	0.339	9.7–35.1
β-CTX (µg/L)	0.594 ± 0.24	0.404 ± 0.18	0.197	< 0.573
tPINP (µg/L)	114.6 ± 78.3	85.6 ± 27.6	0.496	15.2–58.59

mean ± SD · TH n: 30 / 7 · bone markers in 11–12 (A) and 5–6 (B) patients · RR: reference range

aBMD change from baseline at 12 and 24 months





■ Group A (TPTD)
■ Group B (Ca + vit D)

TBS at 12 months: +7.0% vs +0.7% (p = 0.086) / 24-month n: 24 vs 9

aBMD % change from baseline over 7 years

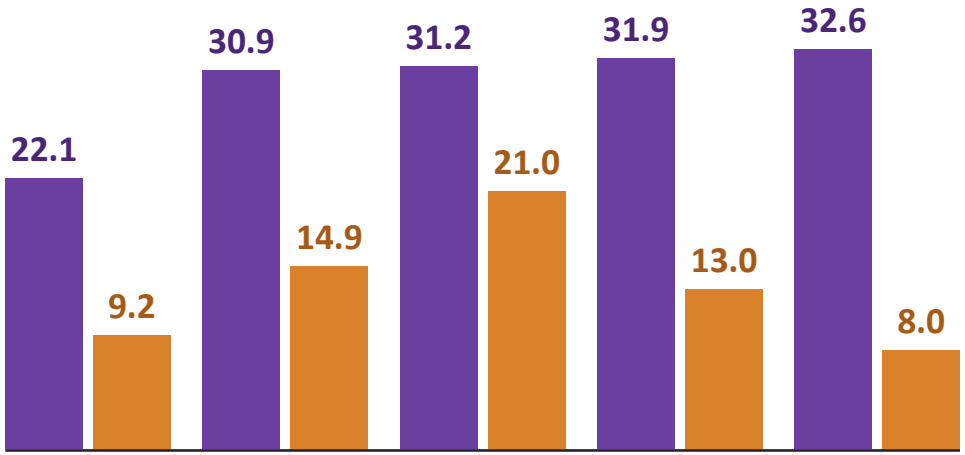
	Lumbar spine				Total hip			
	n (A / B)	Group A	Group B	p	n (A / B)	Group A	Group B	p
Year 1	30 / 12	22.1 †	9.2 †	**0.001**	29 / 8	10.4 †	4.2	0.131
Year 2	24 / 9	30.9 †	14.9 †	**< 0.001**	24 / 10	13.3 †	7.1	0.316
Year 3	22 / 8	31.2 †	21.0 †	0.129	21 / 7	14.6 †	7.2	0.330
Year 5	14 / 4	31.9 †	13.0	0.100	12 / 3	13.2 †	NA	—
Year 7	7 / 2	32.6 †	8.0	0.143	7 / 2	11.1 †	NA	—

- LS Z-score at 2 years: **−1.44** (Group A) vs **−2.29** (Grooup B), p = 0.040 — baseline −3.2 vs −2.9

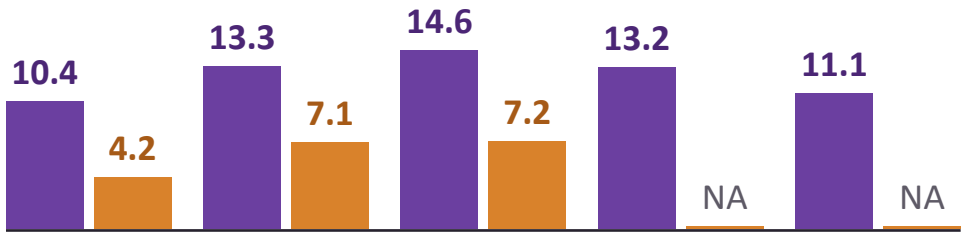
Mean % change from baseline · † within-group p < 0.05 vs baseline · Group A: TPTD · Group B: Ca + vit D · NA: not available

Sustained aBMD gain with TPTD up to 7 years

Lumbar spine — % change

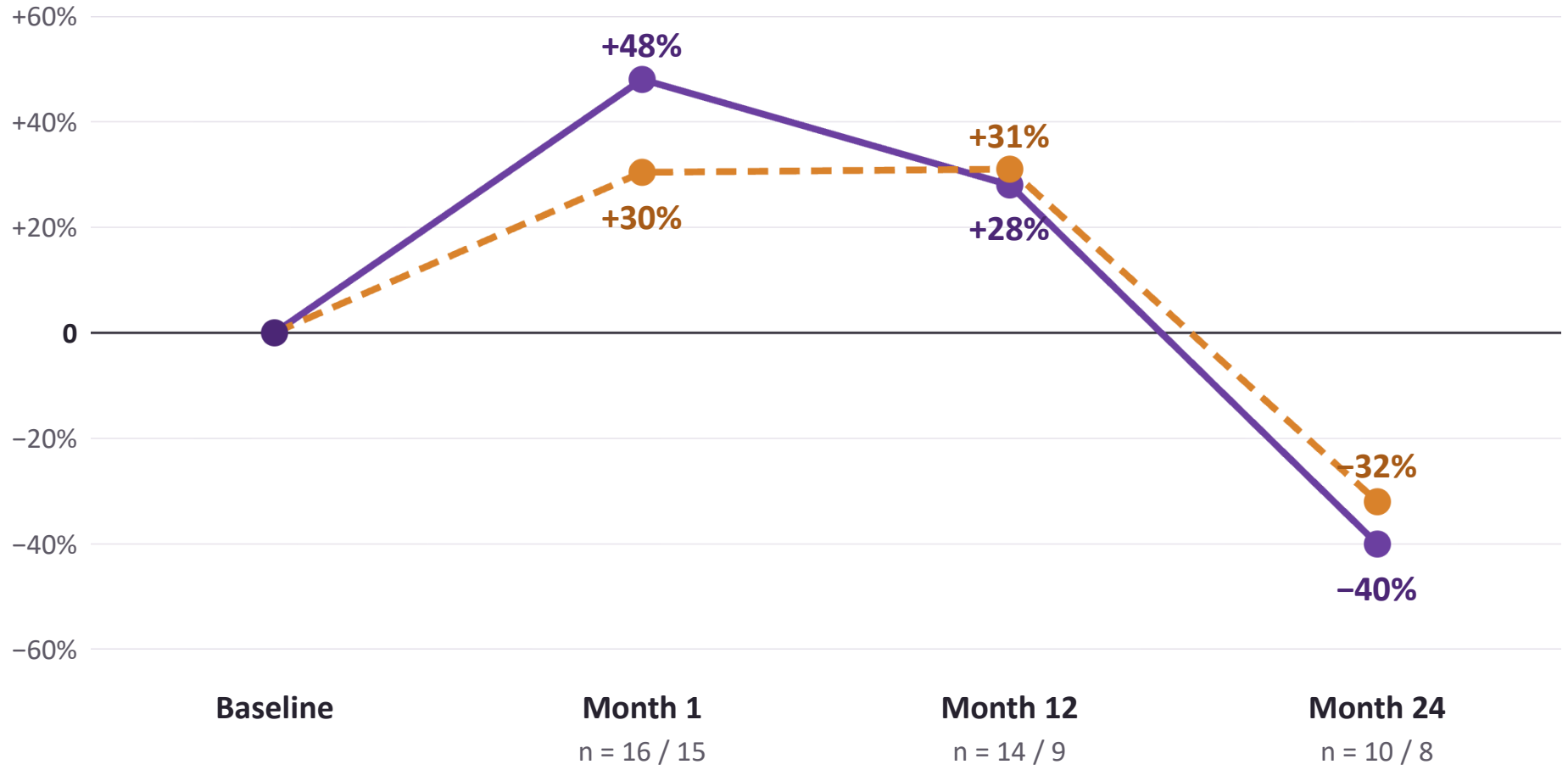


Total hip — % change



■ Group A (TPTD)
■ Group B (Ca + vit D)
between-group p under each year
within-group change significant at all time points in group A

Bone turnover markers during teriparatide



PINP

β-CTX

Friedman test:
PINP $p < 0.05$, CTX $p = 0.012$

Mean % change from baseline in group A (TPTD) · n = PINP / CTX · time points evenly spaced, not to scale

Bone turnover markers in the TPTD group

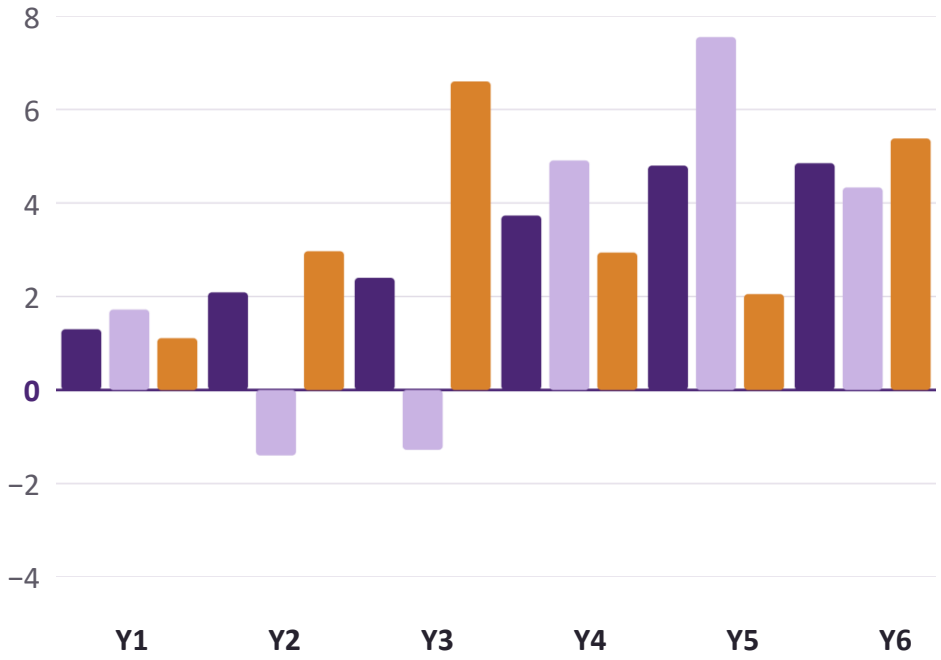
- Month 1: PINP **+48%**, CTX **+30%** · month 12: +28% and +31% · month 24: **–40%** and **–32%** vs baseline
- PINP and CTX at 1 month **correlated with the aBMD gain** at both sites for 3 years

	Year 1		Year 2		Year 3		Year 5	
ρ with aBMD % change	**LS**	**TH**	**LS**	**TH**	**LS**	**TH**	**LS**	**TH**
PINP at 1 month	0.60*	0.44*	0.56*	0.63*	0.66*	0.64*	−0.12	0.68
PINP % change, 1 month	0.14	−0.11	0.16	−0.01	0.38	0.18	0.26	0.14
CTX at 1 month	0.62*	0.49*	0.66*	0.73*	0.75*	0.68*	−0.05	0.77
CTX % change, 1 month	0.37	0.46	0.39	0.66*	0.50	0.63*	−0.24	0.60

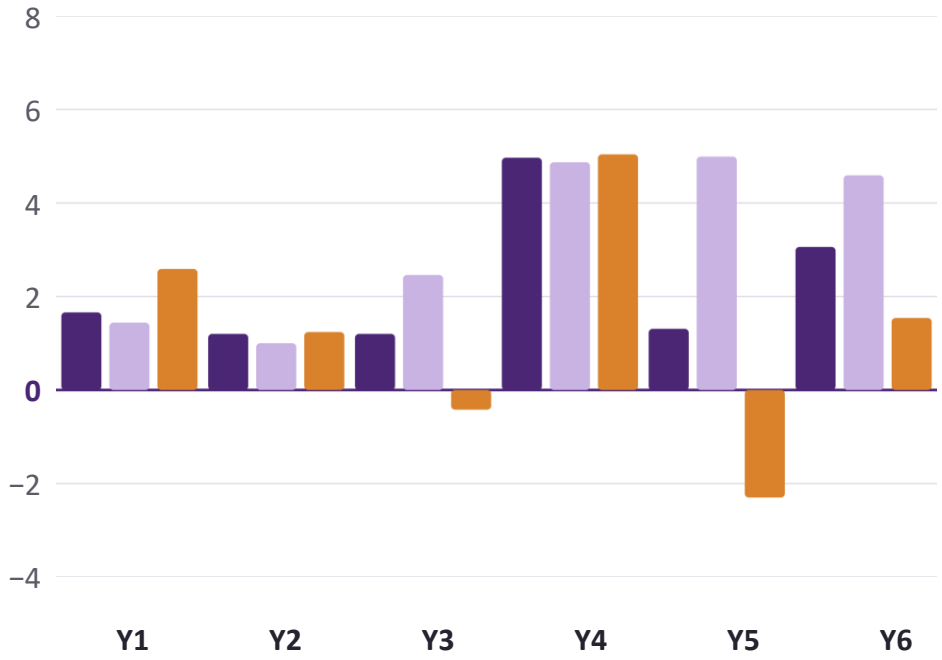
Spearman ρ · * $p < 0.05$ · Friedman $p < 0.05$ (PINP), $p = 0.012$ (CTX) · month 1: n = 16 / 15

aBMD after stopping teriparatide

Lumbar spine — yearly % change in aBMD



Total hip — yearly % change in aBMD



- All patients
- No subsequent treatment (n=11)
- Bisphosphonates or denosumab (n=15)

no significant difference between subgroups

Fractures and subsequent pregnancies

- **No incident vertebral fractures** during TPTD treatment
- One kyphoplasty (4 vertebrae) right after fracture confirmation

New pregnancy during follow-up

	Group A	Group B
Another pregnancy, n	6	4
Recurrent back pain, n	3	2
Vertebral bone marrow oedema, n (%)	1 (17)	1 (25)

Our results compared with published studies

Study	Design	n TPTD / CaD	Follow-up	LS aBMD change	Main message
Laroche 2017, France	Retrospective	52 (TPTD, BP, none)	4–36 mo	Annual gain: TPTD 14.9%, BP 10.2%, none 6.6%	New fractures 19%, mostly untreated
Lee 2021, Korea	Retrospective	33 / —	3 y	3 y: +24.0% with vs +23.4% without sequential ART	Gain maintained without sequential therapy
Hadji 2022, Germany	Uncontrolled	47 / —	36 mo (24 on TPTD + 12 off)	+21.1% (1 y); +31.4% (2 y)	Maintained 12 mo after stopping; 4/47 new VFs
Gürkan 2025, Türkiye	Retrospective	9 / —	mean 40 mo (~2.3 y off TPTD)	+13.9% (1 y); +24.4% (end of follow-up)	BMD kept rising after a ~6-month course
Sözen 2026, Türkiye	Multicenter retrospective	22 / 24	up to 2 y	19.1% vs 9.5% (1st visit*, p = 0.019); 31.1% vs 15.4% (2nd visit, NS)	No independent TPTD effect after adjustment
Lynch & Cohen 2026, USA	Registry	31 / —	12 mo	+21% if started < 12 mo postpartum vs +8% if later	Earlier start → 2–3× greater gain
Present study	Retrospective	34 / 13	A: 51 (15–96) mo B: 46 (16–82) mo	22.1% vs 9.2% (1 y); 30.9% vs 14.9% (2 y)	Gain sustained up to 7 years

* Sözen: visits at ~6 / 18 mo for TPTD vs ~12 / 24 mo for CaD · Laroche M, Osteoporos Int 2017 · Lee S, Calcif Tissue Int 2021 · Hadji P, Geburtshilfe Frauenheilkd 2022 · Gürkan E, Clin Transl Metab 2025 · Sözen M, Front Endocrinol 2026 · Lynch LK, Osteoporos Int 2026 · BP: bisphosphonates · ART: antiresorptive

Discussion

Our findings in context

- Recent reviews: still **no guidelines**; an **anabolic is preferred** when treatment is needed

Gak N, Abbara A, Dhillo WS, Keen R, Comninos AN. Current and future pregnancy and lactation-associated osteoporosis. Front Endocrinol
Kovacs CS. Pregnancy and lactation associated bone fragility. J Endocr Soc

- **2026 position statement** (IAPM, IOF, ECTS, ESCEO, IMS, EMAS): ≥ 2 fractures → teriparatide/abaloparatide or romosozumab first; after TPTD, **no follow-up treatment needed** if menses resume.

Hadji P, Athanasiadis A, Brandi ML, et al. Pregnancy- and lactation-associated osteoporosis: a position statement of the IAPM, IOF, ECTS, ESCEO, IMS, and EMAS. Int J Gynecol Obstet 2026; doi:10.1002/ijgo.71203.

Limitations

- Retrospective design
- Small control group; attrition
- More VFs in the TPTD group (indication bias)
- Incomplete TBS and marker data
- Not powered for fractures

Conclusions

In women with PLO, teriparatide was associated with a **greater and more durable** improvement in BMD at the lumbar spine and total hip compared with conservative management.

- LS: +22% vs +9% at 1 year, +31% vs +15% at 2 years
- **Gain maintained** for up to 7 years after TPTD completion (with or without antiresorptives)
- Early PINP and CTX as **predictors of response**
- Prospective controlled studies are needed

References

1 Nordin BE, Roper A. Post-pregnancy osteoporosis; a syndrome? Lancet 1955;268:431–34

2 Kovacs CS, Ralston SH. Presentation and management of osteoporosis presenting in presenting in association with pregnancy or lactation. Osteoporos Int 2015;26:2223–41 2015;26:2223–41

3 Anagnostis P, Lampropoulou-Adamidou K, Bosdou JK, et al. Comparative effectiveness of therapeutic interventions in PLO: systematic review and meta-analysis. JCEM 2023; doi:10.1210/clinem/dgad548

4 Butscheidt S, Tsourdi E, Rolvien T, et al. Relevant genetic variants are common in women with PLO. Bone 2021;147:115911

5 Kyvernitakis I, Reuter TC, Hellmeyer L, et al. Subsequent fracture risk of women with PLO after a median of 6 years. Osteoporos Int 2018;29:135–42

6 Laroche M, Talibart M, Cormier C, et al. Pregnancy-related fractures: a French cohort of 52 patients. Osteoporos Int 2017;28:3135–42

7 Cohen A, Kamanda-Kosseh M, Dempster DW, et al. Women with PLO have low bone remodeling rates at the tissue level. JBMR 2019;34:1552–61

8 Hong N, Kim JE, Lee SJ, et al. Changes in BMD and bone turnover markers during teriparatide in PLO. Clin Endocrinol (Oxf) 2018;88:652–58

9 Lampropoulou-Adamidou K, Trovas G, Triantafyllopoulos IK, et al. Teriparatide treatment in patients with PLO. Calcif Tissue Int 2021;109:554–62

10 Lampropoulou-Adamidou K, Trovas G, Stathopoulos IP, Papaioannou NA. Teriparatide in a case of severe PLO. Hormones (Athens) 2012;11:495–500

11 Lee S, Hong N, Kim KJ, et al. Bone density after teriparatide discontinuation with or without antiresorptive therapy in PLO. Calcif Tissue Int 2021;109:544–53

12 Hadji P, Mouzakiti N, Kyvernitakis I. Effect of teriparatide on subsequent fracture and BMD in 47 women with PLO and vertebral fractures. Geburtshilfe Frauenheilkd 2022;82:619–26

13 Gak N, Abbara A, Dhillo WS, Keen R, Comninos AN. Current and future perspectives on PLO. Front Endocrinol 2024;15:1494965

14 Gürkan E. Could the effect of teriparatide on PLO be long-term? Clin Transl Metab 2025;23; doi:10.1007/s12018-025-09307-9

15 Kovacs CS. Pregnancy and lactation associated bone fragility. J Endocr Soc 2025;9:bvaf126

16 Sözen M, et al. Real-world treatment outcomes in PLO: a nationwide multicenter cohort study. Front Endocrinol 2026;17:1934166

17 Orhadje E, Berg K, Hauser B, Ralston SH. Clinical features, incidence and treatment outcome in pregnancy-associated osteoporosis. Calcif Tissue Int 2023;113:591–96

18 Kasahara K, Tanaka-Mizuno S, Tsuji S, et al. PLO as a major type of premenopausal osteoporosis: a real-world cohort. BMC Pregnancy Childbirth 2024;24:301

19 Hadji P, Athanasiadis A, Brandi ML, et al. PLO: a position statement of the IAPM, IOF, ECTS, ESCEO, IMS, and EMAS. Int J Gynecol Obstet 2026; doi:10.1002/ijgo.71203

Thank you!



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ΕΡΓΑΣΤΗΡΙΟ ΕΡΕΥΝΑΣ ΜΥΟΣΚΕΛΕΤΙΚΩΝ ΠΑΘΗΣΕΩΝ
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