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Alveolar Bone Mineral Density Correlates with Lumbar Spine Bone Mineral Density During Romosozumab Therapy: A Prospective Observational Study In Osteoporosis

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Article

Keywords: Alveolar bone mineral density (al-BMD), Osteoporosis, Bone mineral density (BMD), Dental radiographs, Bone metabolic markers, Osteoporosis therapy

Posted Date: September 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10663648/v1

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Additional Declarations: No competing interests reported.

Abstract

Early osteoporosis detection remains challenging because of the limited accessibility of dual-energy X-ray absorptiometry (DXA), sparking interest in the use of routine dental radiographs to assess alveolar bone mineral density (al-BMD). This prospective observational study evaluated the longitudinal changes in al-BMD during osteoporosis therapy, its association with systemic BMD and its utility as a screening and monitoring tool in female patients. al-BMD was quantified using standardized intraoral radiographs with reference phantoms, while systemic BMD and bone turnover markers were concurrently monitored. At baseline, al-BMD was significantly lower in patients with untreated osteoporosis than in both young and elderly non-osteoporotic controls. Receiver operating characteristic analysis demonstrated high diagnostic performance for al-BMD in identifying untreated osteoporosis, showing a positive correlation with the lumbar spine BMD but not with the femoral neck BMD and the total hip BMD. During sequential bone-anabolic therapy, al-BMD significantly increased over time, eventually reaching levels comparable to those of elderly non-osteoporotic controls. Also, al-BMD changes like those observed in systematic BMD. These findings suggest that al-BMD derived from dental radiographs is a clinically promising adjunct for osteoporosis screening and monitoring treatment-associated bone improvements.

Introduction

Osteoporosis is a “disease characterized by decreased bone strength leading to an increased risk of fracture,” [1] and the WHO defines osteoporosis as “a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture.” [2]. In Japan, the prevalence of osteoporosis was estimated to be 15.9 million as of 2015 [1], and due to the rapid aging of the population, it continues to increase annually.

Primary osteoporosis is characterized by increased bone fragility due to decreased bone mineral density resulting from accelerated bone remodeling, bone structure deterioration, reduced secondary mineralization, and changes in bone matrix proteins [3]. Fragility fractures caused by this disease not only decrease patients' QOL but also directly lead to a poorer life prognosis, making osteoporosis screening aimed at early detection and appropriate intervention essential [1, 4]. Currently, osteoporosis screening is conducted by local municipalities for female aged 40–70 years using peripheral bone mineral density measurements or quantitative ultrasound (QUS) bone density testing. However, the gold standard for diagnosis, dual-energy X-ray absorptiometry (DXA), is limited at the screening level because of factors such as limited dissemination of equipment and cost, and early detection of osteoporosis remains a significant challenge.

Against this background, osteoporosis screening using dental X-ray images taken during routine clinical practice has attracted attention [5]. It has already been demonstrated that the assessment of the mandibular inferior cortical bone morphology on panoramic radiographs is useful for osteoporosis screening [6]. More recently, alveolar Bone Mineral Density (al-BMD) has been measured using dental

radiographs, which is an even less invasive and simpler method. However, there is still insufficient consensus regarding the reliability of al-BMD as an indicator of systemic bone mineral density [7].

In this study, we prospectively observed and measured changes in al-BMD and total body bone mineral density in patients with osteoporosis before the initiation of treatment and throughout the treatment course. This study aimed to examine fluctuations in al-BMD during treatment, its correlation with total body bone, and to evaluate whether al-BMD is useful as a screening tool for the early detection of osteoporosis and monitoring of bone mineral density during treatment.

Materials and Methods

2 – 1. Study Design

This prospective observational study included 63 patients diagnosed with osteoporosis at the Department of Orthopedic Surgery, Kumamoto University Hospital, between 2024 and 2025, who were referred to the Department of Oral and Maxillofacial Surgery, Kumamoto University Hospital, for intraoral examination prior to the initiation of osteoporosis treatment. All participants were female. 12 patients with a history of osteoporosis treatment were excluded (Fig. 1a). The study protocol was reviewed and approved by the Ethics Committee of Kumamoto University (approval number: RINRI 2287) and was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their enrollment in the study. All data were handled in an anonymized manner, and no personally identifiable information is presented in this manuscript.

2–2. Treatment and Research Schedule

Figure 1b shows the osteoporosis treatment and measurement schedule. Following an evaluation prior to the start of treatment (Baseline: 0M), Romosozumab were administered for 12 months. To track changes over time during the treatment period, each parameter was measured continuously at the specified follow-up intervals.

2–3. Measurement of bone turnover markers

Bone-type tartrate-resistant acid phosphatase (TRACP-5b) and type I collagen N-terminal pro-peptide (P1NP) levels were serologically evaluated at baseline (0M) and at 1, 6, and 12 months after the start of treatment.

2–4. Bone Mineral Density Measurement

Bone mineral density (BMD) was measured at baseline, 6 months, and 12 months using dual-energy X-ray absorptiometry (DXA) (Kumamoto University Hospital: Lunar iDXA, GE Healthcare, Madison, WI, USA)

at the lumbar spine (L2-L4) (LS BMD), the total hip (TH BMD) and the femoral neck (FN BMD).

2–5. Alveolar Bone Density Measurement

al-BMD was measured at baseline, 6, 12 months. A computer-assisted image analysis system (DentalSCOPE®; Media Corporation, Tokyo, Japan) was used to measure the al-BMD (Fig. 1c). DentalSCOPE® consists of dedicated intraoral radiographic indicators and analysis software. Intraoral radiographs were obtained using a specialized indicator equipped with reference phantoms containing calcium carbonate standards (500, 1000, and 1500 mg/cm²) (Fig. 1c-a). The analysis software automatically generated a calibration curve based on the image density of the phantom and converted the density values of the region of interest (ROI) into al-BMD values (mg/cm²). Intraoral radiographs were acquired using imaging plates (IP) with MaxiX Type2® (J. Morita Manufacturing Corp., Kyoto, Japan). The IP was scanned using a CS7600 CR System (Asahi Roentgen Ind. Co., Ltd., Kyoto, Japan). The X-ray image data were imported into DentalSCOPE® software, and the ROI was set for the proximal and distal alveolar bone of the mandibular first premolar (Fig. 1c-b). Evident bone resorption areas due to periodontitis or apical periodontitis, loss of either mandibular first premolar, and edentulous regions were excluded from the ROI [8]. In this study, 44 healthy young females in their 20s and 31 elderly females without osteoporosis aged 50–80s participated as volunteers, and al-BMD was similarly measured. Calculation of the al-BMD T-score (al-T-score) followed the diagnostic criteria for primary osteoporosis revised by the Japanese Society for Bone and Mineral Research (JSBMR) in 2012, and was calculated as ((measured al-BMD g/cm²) – (mean al-BMD g/cm² of young female)) / (standard deviation SD of young female). al-BMD Young Adult Mean (al-YAM) was calculated as (measured al-BMD g/cm²) / (mean al-BMD g/cm² of young females) × 100 [9].

2–6. Statistical Analysis

All statistical analyses were performed using EZR (Jichi Medical University Saitama Medical Center, Saitama, Japan) [10]. ROC curve analysis was conducted to evaluate the usefulness of al-BMD as a screening tool for osteoporosis. The diagnostic accuracy of al-BMD for identifying osteoporosis was assessed using the Area Under the Curve (AUC), and the cutoff value was determined based on the Youden Index. Quantitative data are presented as mean ± standard deviation (SD). Differences between the al-BMD groups and temporal changes from baseline were compared using Ranked ANOVA. Furthermore, Dunnett's multiple comparison test was used to evaluate the significance of differences between each group and the control group, while the Mann–Whitney U test was used to assess the statistical significance between two groups. Statistical significance was set at $p < 0.05$ (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, NS: not significant). Spearman's rank correlation analysis was used to assess the correlation of al-BMD with LS BMD, TH BMD and FN BMD, as well as the correlation between the rate of change in TRACP and P1NP at 1 month after initiation of treatment (ΔTRACP, ΔP1NP) and the percentage change in each BMD at 12 months. To maximize the sample size for the correlation analysis, pooled data from all measurement time points (baseline, 6, and 12 months) were used.

Results

3.1 Characteristics of Osteoporosis Patients at Baseline

Table 1 presents the baseline characteristics of the participants. The mean age of the patients was 64.7 years, and no skeletal disorders were reported. 40% of the participants had a history of fragility fractures. The mean FN BMD at baseline was 0.52 ± 0.14g/cm², TH BMD was 0.63 ± 0.13 g/cm², LS BMD was 0.74 ± 0.22 g/cm², and al-BMD was 0.69 ± 0.10g/cm². The TRACP-5b value were 404.8 ± 221.2 mU/dL, and the P1NP value were 80.5 ± 47.3 ng/mL, respectively.

Table 1
Characteristics of Patients with Osteoporosis at baseline

Variable		**n = 51**	**%**
Age(years)		64.7 ± 15.6	-
Sex (female)		51	100
Body mass index(kg/m²)		19.5 ± 2.9	-
Height(cm)		153 ± 7.3	-
Weight(kg)		45.6 ± 7.7	-
Skeletal disorders	-	51	100
History of fragility fracture	+	20	39.2
Active vitamin D3 analogs	-	17	33.3
	+	34	66.7
Femoral neck BMD(g/cm²)		0.52 ± 0.14	-
Femoral neck BMD(T-score)		-4.28 ± 1.97	-
Total hip BMD(g/cm²)		0.63 ± 0.13	-
Total hip BMD(T-score)		-3.44 ± 1.63	-
Lumbar spine BMD(g/cm²)		0.74 ± 0.22	-
Lumbar spine BMD(T-score)		-3.25 ± 1.70	-
Alveolar BMD(g/cm²)		0.69 ± 0.10	-
Alveolar BMD(T-score)		-1.58 ± 0.66	-
TRAP-5b(mU/dL)		404.8 ± 221.2	-
P1NP(ng/mL)		80.5 ± 47.3	-

Values are expressed as Mean ± standard deviation. Abbreviation: TRAP-5b, Tartrate-resistant acid phosphatase 5b; P1NP, type collagen N-terminal propeptide.

3.2 Cut-off value and effectiveness of al-BMD in identifying untreated osteoporosis patients

To assess the clinical utility of al-BMD for osteoporosis screening in untreated cases, a receiver operating characteristic (ROC) curve analysis was conducted on the patients' baseline al-BMD. The area under the curve (AUC) for both al-T-score (Fig. 2a) and al-YAM was 90 (95% confidence interval of 0.73-1.00) (Fig. 2b). The positive predictive value was 60%, negative predictive value was 100%, false-positive

rate was 27.3%, and false-negative rate was 0.0%. The cutoff values for identifying osteoporosis were −0.65 for the al-T-score and 88% for the al-YAM.

3.3 The al-BMD of patients with osteoporosis was significantly lower than that of young and elderly females without osteoporosis.

To compare al-BMD between individuals with osteoporosis and healthy controls, measurements were taken in the mandibular first premolar region (Fig. 3). The mean al-BMD for females in their 20s was 0.94 ± 0.17 g/cm². In contrast, elderly females without osteoporosis exhibited a mean al-BMD of 0.88 ± 0.19 g/cm², with a mean al-T-score of -0.38 ± 1.14. Patients with untreated osteoporosis demonstrated a mean al-BMD of 0.69 ± 0.11 g/cm² and a mean al-T score of -1.58 ± 0.66. The al-BMD in patients with osteoporosis was significantly lower than that in both young and elderly females without osteoporosis ($p < 0.001$, Fig. 3).

3.4 A positive correlation was observed between al-BMD and LS BMD in patients with osteoporosis.

To assess the validity of using al-BMD for systemic bone density evaluation, Spearman's rank correlation analysis was conducted to examine the relationship between al-T-score and LS, TH, FN T-score in patients with osteoporosis undergoing treatment. A significant positive correlation was identified between al-T-score and LS T-score (0.28, $p = 0.009$, Fig. 4a), whereas no significant correlation was detected between alT-score and TH T-score (-0.05, $p = 0.70$, Fig. 4b), FN T-score, (-0.02, $p = 0.88$, Fig. 4c).

3.5 With the use of Romosozumab, al-BMD increases, showing changes like those observed in the total body bone.

To assess the therapeutic response to osteoporosis treatment, bone turnover markers, specifically TRACP-5b (indicative of bone resorption) and P1NP (indicative of bone formation), were measured at baseline, 6 months, and 12 months. The rate of change from baseline in TRACP-5b demonstrated a decreasing trend at 1, 6, and 12 months, with reductions of 14.5%, 10.5%, and 23.6%, respectively. A statistically significant difference was noted between baseline and 1 month ($p < 0.001$, Fig. 5a), as well as between baseline and 12 months ($p < 0.05$, Fig. 5a). In contrast, the rate of change in P1NP showed a significant increase of 7% to 111.7% at 1 month ($p < 0.001$), followed by a decrease to 60.9% at 6 months and 6.9% at 12 months (Fig. 5b). In addition, to assess the alterations in al-BMD throughout osteoporosis treatment, measurements were conducted at each treatment phase (0, 6, 12 months) and analyzed using the Friedman test (Ranked ANOVA) and Dunnett's multiple comparison test. At 6 months post-treatment initiation, al-BMD was recorded at 0.72 ± 0.14 g/cm² and the al-T-score was − 1.3 ± 0.83, with no statistically significant change from the baseline ($p = 0.77$). At 12 months, al-BMD increased to 0.77 ± 0.21 g/cm² and the al-T-score improved to -0.83 ± 0.95, demonstrating a significant increase from baseline ($p = 0.02$, Fig. 5c). As Fig. 5D, to determine whether changes in al-BMD corresponded with systemic bone density changes, the rate of change from the baseline was calculated. BMD increased across all regions—FN, TH, LS and al-BMD—with LS BMD exhibiting the highest rate of inc7%se (12.7%)

at 6 months, followed by a3%BMD (5.3%), 4%BMD (3.4%), 3%BMD (3.3%). From 6 to 12 months, all regions demonstrated a similar rate of increase, and at 12 months, the cumulative rate of increase from the baseline was 17.7% for the lumbar spine, 9.1% for the alveolar bone, 7.8% for the Femoral neck bone and 7.5% for the total hip.

Discussions

In this research, we explored the progression of al-BMD in women diagnosed with osteoporosis over a 12-month treatment period. Our analysis involved comparing al-BMD measurements between young women and those with osteoporosis. Additionally, we investigated the correlation between al-BMD and systemic bone mineral density during the treatment to determine the effectiveness of al-BMD as a diagnostic tool for osteoporosis.

The ROC curve analysis suggested that al-BMD may be a valuable parameter for osteoporosis screening. al-BMD can be routinely and minimally invasively measured within dental practice, potentially facilitating early detection and screening for osteoporosis treatment. Furthermore, it may offer benefits for risk assessment and prevention of MRONJ onset through regular dental visits. This underscores the significance of future medical–dental collaboration [5]. However, to ascertain the true utility of this parameter for osteoporosis screening, further studies involving a large number of randomly selected cases are necessary, which remains a challenge for future studies. al-BMD is significantly reduced in patients with osteoporosis. This finding aligns with previous studies indicating that al-BMD in the osteoporosis cohort was substantially lower than that in the control group (1.125 vs. 1.355 g/cm²) [11]. Additionally, it corroborates reports of decreased alveolar bone height and density over a two-year follow-up period in postmenopausal female with osteoporosis and osteopenia [12]. Conversely, Mohajery et al. noted the challenges in identifying patients with osteoporosis using oral indices, such as jawbone density [13]. This discrepancy can be attributed to the anatomical characteristics of the measurement sites. Their analysis focused on areas with predominantly cortical bone and slow metabolic turnover, such as the mandibular angle, or regions where reduced bone density is obscured by occlusal forces, such as the alveolar hard line. In this study, the mandibular first premolar region was selected because of the predominance of cancellous bone within the mandible, allowing for analysis under conditions that minimize local biases, such as excessive occlusal force load observed in molar regions or significant anatomical individual differences in bone thickness, as seen in anterior regions. Nonetheless, factors such as the progression of periodontitis and occlusal force cannot be entirely excluded. Future research should investigate the severity of periodontitis and occlusal status and conduct multivariate analyses incorporating local factors as variables for validation.

Our analysis revealed a significant positive correlation between al-BMD and LS BMD in patients with osteoporosis. However, no correlation was identified between FN BMD, TH BMD, and al-BMD in the same patient group. This site-specific correlation is believed to be due to the common anatomical characteristics of the lumbar spine and mandibular premolar region, both of which have a high proportion of trabecular bone and rapid metabolic turnover [14.15]. The reports by Takaishi et al. [16] and

Taguchi et al. [17] on Japanese female, as well as the study by López-López et al., which similarly found that the mandibular bone correlated only with lumbar spine bone density and not with femoral bone density [18], support our findings. However, some studies have reported no correlation or only a weak correlation between al-BMD and LS BMD [19], as well as a correlation only with the femur [11]. Such discrepancies among reports are presumed to be influenced by factors such as comparisons not limited to osteoporosis onset but including all postmenopausal female, differences between edentulous and dentate individuals, and—most importantly—differences in bone density measurement methods. Currently, analyses of mandibular bone density involve various methods, including analysis using DXA forearm software, CT value analysis using CBCT, and post-dental imaging software such as Bone Right® [20], DentalSCOPE®, and Radiograph Workshop® [21], resulting in a lack of consistent views regarding their associations with systemic bone. The novelty of this study lies in its focus on patients with osteoporosis and examination of clinically important correlations among al-BMD, LS BMD, FN BMD and TH BMD. According to a systematic review by Chai et al., few studies have reported on the correlation between mandibular and skeletal bone density limited to patients with osteoporosis; moreover, none of the five studies cited met the Newcastle-Ottawa Scale (NOS) criteria, highlighting a lack of high-quality clinical research [22]. The present study also had a limited sample size and did not conduct group analyses according to osteoporosis severity or type of medication, nor did it conduct additional analyses considering confounding factors. In the future, multivariate analyses incorporating confounding factors affecting systemic bone metabolism and verification in larger cohorts will be necessary to confirm these findings.

The longitudinal alterations in TRACP-5b and P1NP levels align with findings from prior research [23–25], suggesting an effective pharmacological response to Romosozumab treatment. al-BMD demonstrated significant enhancement as treatment advanced, exhibiting time-dependent changes analogous to those observed in LS, FN and TH BMD. Concerning the notable improvement in al-BMD throughout the treatment course, previous reports have indicated that, in osteoporotic females receiving BP formulations and young females, no statistically significant difference in al-BMD was observed in the mandibular premolar region [8]. This aligns with the current findings, suggesting that al-BMD improved to levels comparable to those of healthy females as a result of osteoporosis treatment. Furthermore, while some studies have reported that changes in mandibular alveolar bone mass (MABM) correlate with changes in systemic BMD [26], experimental animal studies have shown that the administration of alendronate or PTH to ovariectomized rats does not induce changes in mandibular bone characteristics as pronounced as those in the lumbar spine [27]. The results of this study suggest that al-BMD reflects the “current bone mineral density” at each stage of treatment and serves as a useful screening tool to appropriately guide undiagnosed or treatment-interrupted patients with osteoporosis therapy.

This study has several limitations. First, the angle at which the film is positioned during dental radiography is subject to variation. This angle significantly influences the resulting images, and owing to the mandibular morphology and associated pain, achieving a standardized angle for film insertion is challenging. Consequently, standardizing imaging conditions and establishing a quantitative evaluation method remains ongoing challenges [8]. Second, as this was a prospective observational study, the

sample size that could be followed from baseline to 12 months was limited, complicating the precise analysis of correlations with whole-body bone and bone metabolic markers. Therefore, it is imperative to accumulate more cases with continued long-term observation and re-examine the dynamics of al-BMD. Additionally, it will be necessary to perform multivariate analyses adjusted for local oral confounding factors to accurately evaluate the associations with systemic bone.

Conclusion

Analysis of bone density using DentalSCOPE® indicates that this instrument may be beneficial for the early detection and screening of osteoporosis. In female patients with untreated osteoporosis, al-BMD was significantly lower than that in healthy controls. As osteoporosis treatment progressed, al-BMD increased, mirroring the trajectory observed in the systemic bone. Furthermore, al-BMD in female with osteoporosis was correlated with lumbar spine bone mineral density.

Declarations

AI. disclosure statement.

During the preparation. of this work, the authors used Paperpal to check the grammar and assist with the literature search. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the published work.

Competing Interests

The authors declare no competing interests.

Funding

The authors received no specific funding for this work.

Author Contribution

Author contributionsR.Y., H.N., and T.M. conceived and designed the study.H.Y., R.K., R.T., A.H., H.I., H.N., M.H, and T.S. recruited participants and collected the clinical data.R.Y., A.H., T.H., and M.H. analyzed the radiographic images and performed the statistical analyses.R.Y., K.K., and H.Y. drafted the manuscript.All authors interpreted the data, critically revised the manuscript, and approved the final version of the manuscript.

Acknowledgement

The authors thank all the patients who participated in this study. We also acknowledge the dental hygienists and radiology technicians of the Department of Oral and Maxillofacial Surgery at Kumamoto University Hospital for their assistance with patient management and image acquisition.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available because they contain information that could compromise participant privacy but are available from the corresponding author on reasonable request.

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Figures

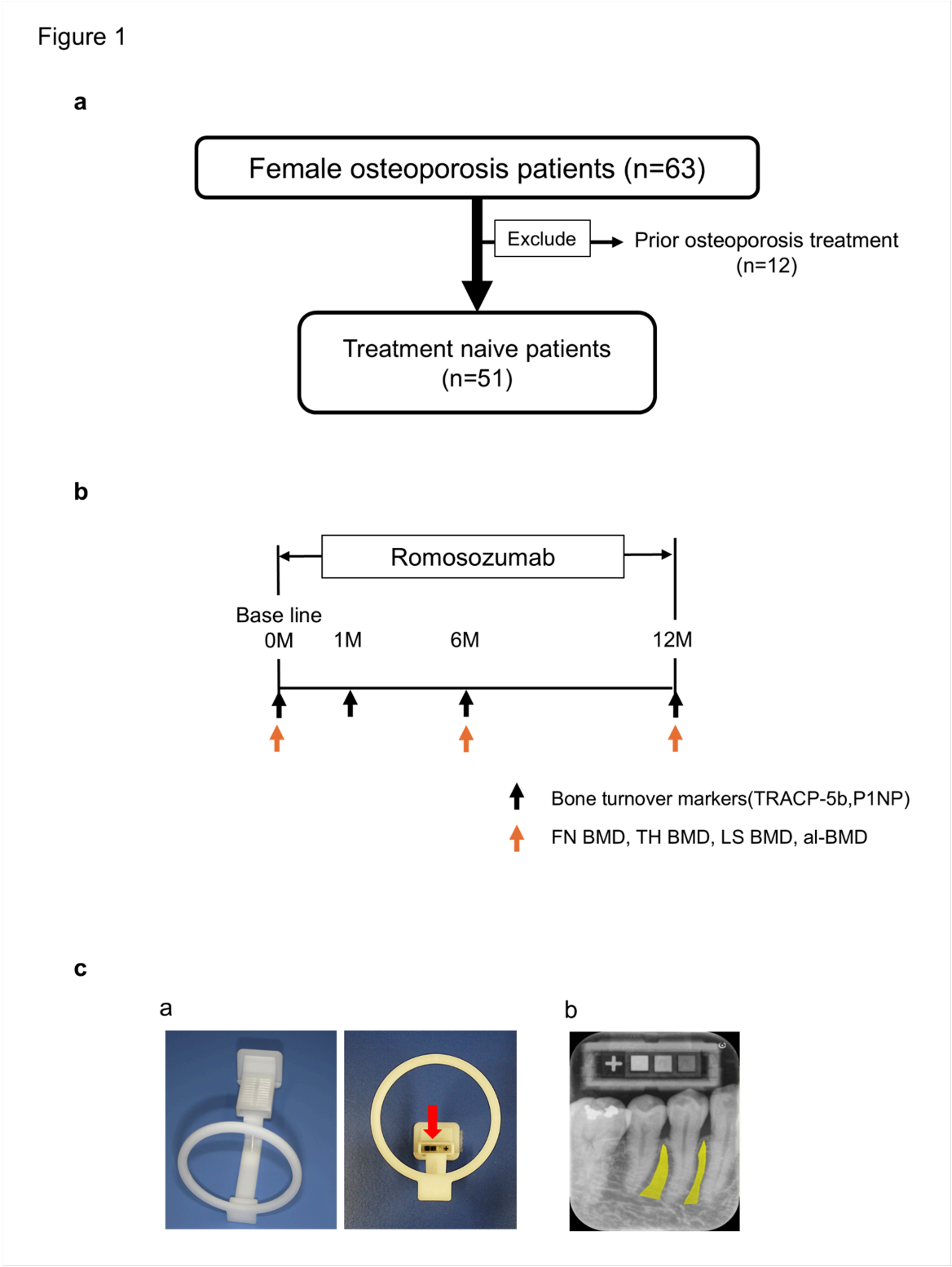


Figure 1

Study Design, Treatment Schedule

a. Study design.

b. Osteoporosis treatment schedule.

Twelve months of bone formation agent therapy Romosozumab was administered from baseline (untreated, 0M). Bone turnover markers (TRACP-5b, P1NP) were measured at 1 month (1M), 6 months (6M), and 12 months (12M) after initiation of treatment; LS and FN, TH and al-BMD were measured at 0M, 6M, and 12M.

c. Measurement of al-BMD using DentalSCOPE®.

(a) Carbonate apatite reference body (red arrow). (b) The indicator was fixed such that the mandibular first molar was centered, and the X-ray apparatus and indicator were positioned parallel to each other. The region of interest (ROI) was set using DentalSCOPE® software, and al-BMD was measured. The yellow area indicates the ROI.

TRACP-5b, Tartrate-resistant acid phosphatase 5b; P1NP, type collagen N-terminal pro-peptide; LS BMD, Lumbar spine BMD; FN BMD, Femoral neck BMD; TH BMD, Total hip BMD; al-BMD, alveolar BMD.

Figure 2

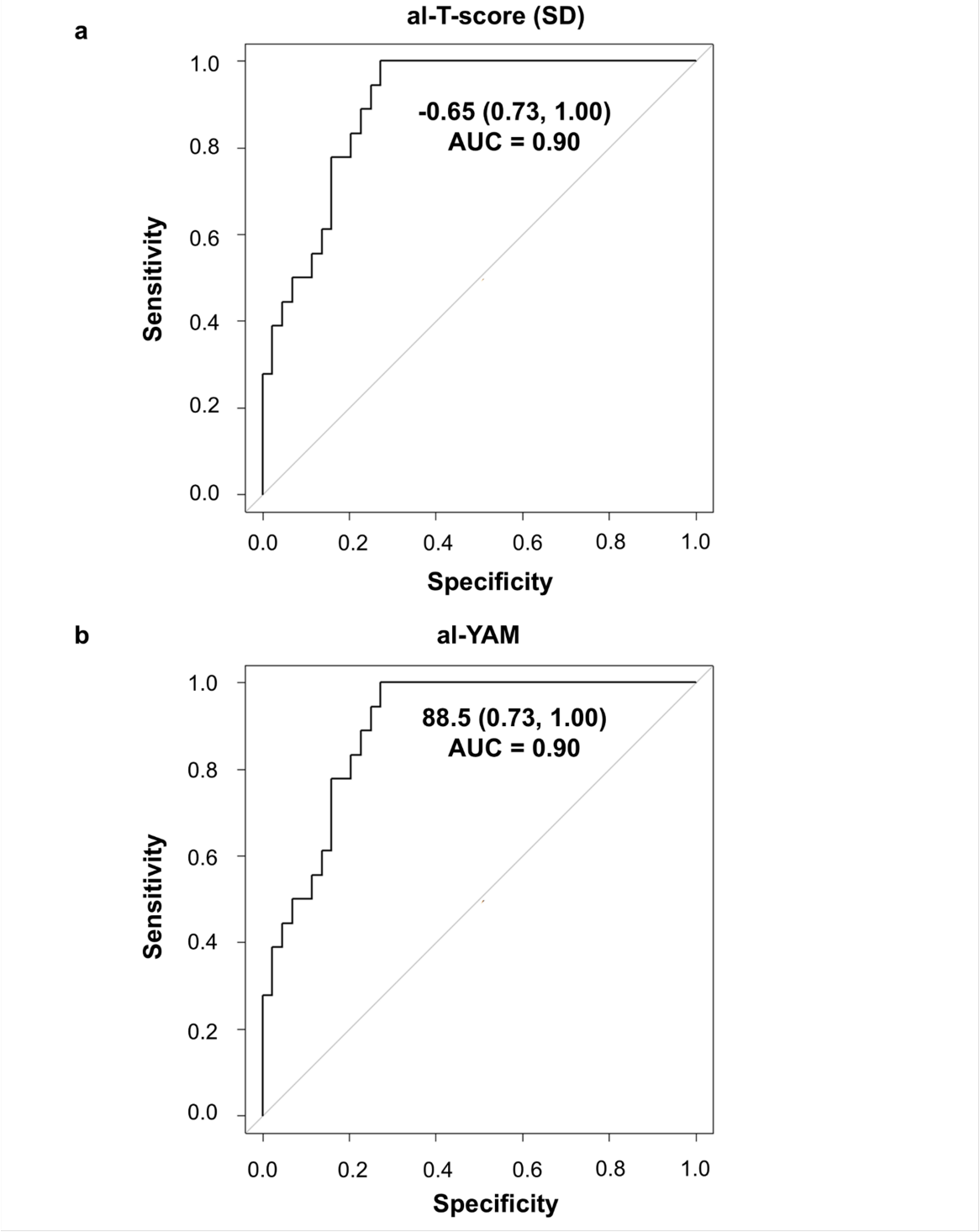


Figure 2

ROC curve and cutoff value of al-BMD for identification of untreated osteoporosis patients

The AUCs of al-T-score and al-YAM for identifying osteoporosis in untreated osteoporosis patients was 0.90 (95% confidence interval: 0.82-0.97). The cutoff values for discriminating osteoporosis were -0.65 for the al-T-score and 88% for the al-YAM.

al-T-score, alveolar Bone T-score; al-YAM, alveolar Bone Young Adult Mean; AUC, Area Under the Curve

Figure 3

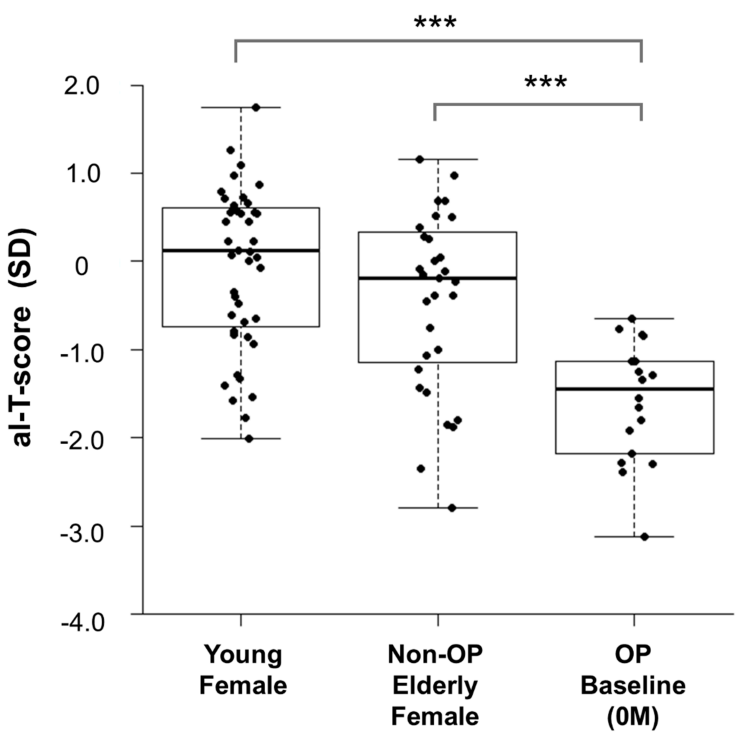


Figure 3

Comparison of al-BMD in untreated females with osteoporosis and females without osteoporosis and the correlation between al-BMD and total bone mineral density.

al-BMD of untreated female with osteoporosis is significantly lower than that of young female

and elderly female without osteoporosis. *p*values were determined using Dunnett's multiple comparison test. ***, $p < 0.001$

al-T-score, alveolar Bone T-score; Non-OP Elderly Woman, Non-Osteoporosis Elderly woman; OP Baseline, Osteoporosis Baseline

Figure 4

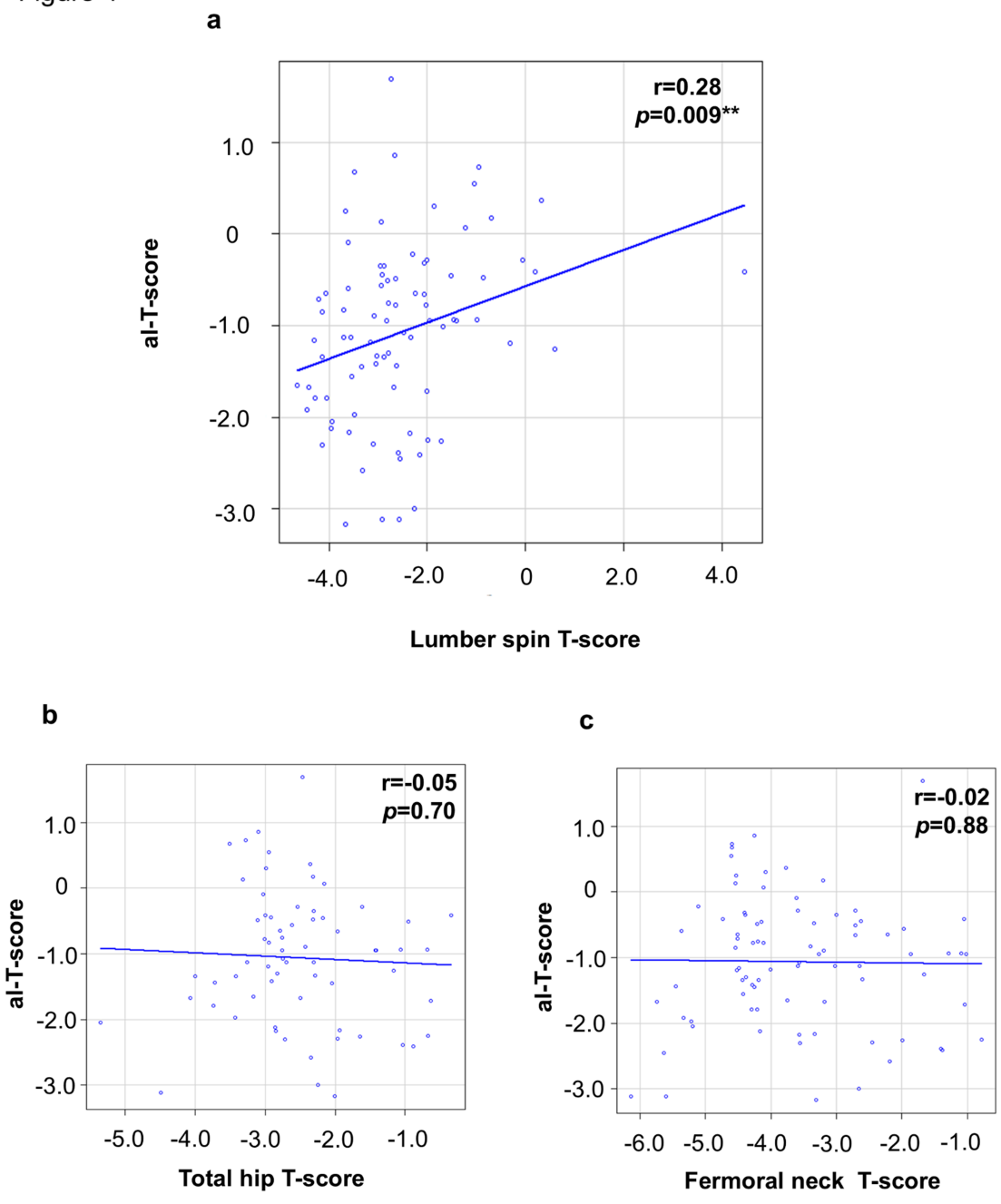


Figure 4

A positive correlation was observed between al-BMD and LS BMD in patients with osteoporosis.

Correlation analysis among alveolar, lumbar spine, femoral neck and total hip T-scores. The correlation coefficient (r) was calculated using Spearman's rank correlation analysis. *p*-values were evaluated using the Mann–Whitney U test. NS, not significance; **, $p < 0.01$

al-T-score, alveolar Bone T-score; Lumber spin T-score, Lumber spin BMD T-score; Femoral neck T-score, Femoral neck BMD T-score; Total hip T-score, Total hip BMD T-score.

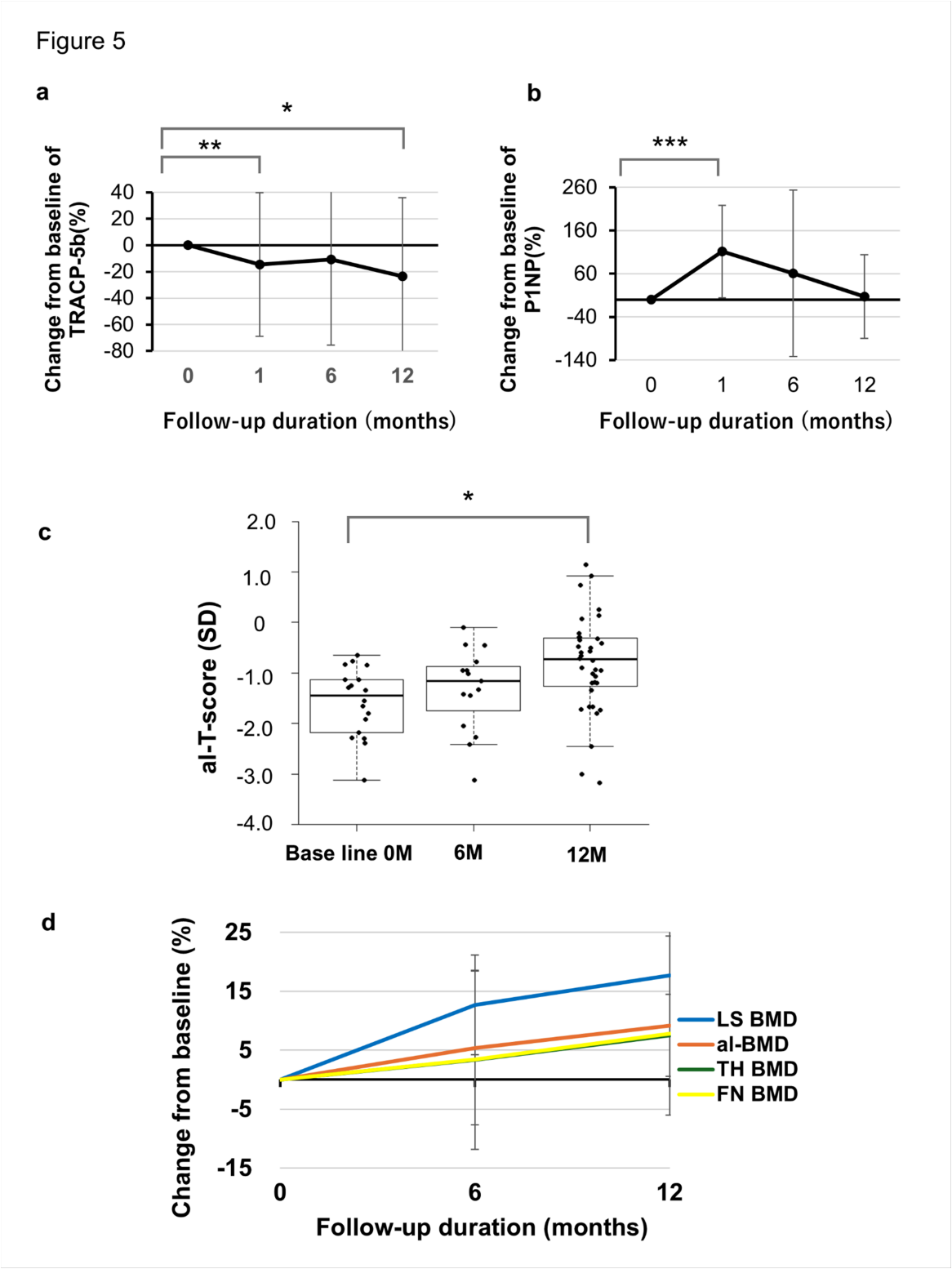


Figure 5

al-T-score improves over the course of treatment, and al-BMD showed an increasing trend like LS, FN and TH BMD.

a. Temporal variations in TRACP-5b from baseline are depicted. The vertical axis represents the percentage change in TRACP-5b, with the baseline set at 0. *p* values were calculated using Dunnett's

multiple comparison test. *, $p < 0.05$; **, $p < 0.01$.

b. Temporal variations in P1NP from baseline are depicted. The vertical axis represents the percentage change in P1NP, with the baseline set at 0. *p* values were calculated using Dunnett's multiple comparison test. ***, $p < 0.001$.

c. Comparison of the changes between al-BMD and total body bone mineral density in patients with osteoporosis during the treatment. *p*-values were assessed using Dunnett's multiple comparison test. *, $p < 0.05$; **, $p < 0.01$.

d. Comparison of changes in alveolar bone density with time-dependent changes in systemic bone density. The vertical axis indicates the percentage change in bone density, with the baseline set to zero. Each bone density value increased over time during treatment.

TRACP-5b, Tartrate-resistant acid phosphatase 5b; P1NP, type collagen N-terminal pro-peptide; al-T-score, alveolar Bone T-score; LS BMD, Lumber spin BMD; FN BMD, Femoral neck BMD; TH BMD, Total hip BMD; al-BMD, alveolar BMD

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.xlsx