

Comparison of Effects of Alendronate and Raloxifene on Lumbar Bone Mineral Density, Bone Turnover, and Lipid Metabolism in Elderly Women with Osteoporosis

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Purpose: To compare the effects of alendronate and raloxifene on lumbar bone mineral density (BMD), bone turnover, and lipid metabolism in elderly women with osteoporosis. **Subjects and Methods:** One hundred twenty-two postmenopausal women with osteoporosis (mean age: 69.4 years) were randomly divided into 2 groups of 61 patients: the alendronate group and the raloxifene group. BMD of the lumbar spine, urinary level of cross-linked N-terminal telopeptides of type I collagen (NTX), and serum levels of alkaline phosphatase (ALP), total cholesterol (TC), high and low density lipoprotein cholesterol (LDL-C and HDL-C, respectively), and triglycerides (TG) were measured during the 12-month-treatment period. **Results:** The trial in 50 patients in the alendronate group and 52 patients in the raloxifene group could be completed. Both alendronate and raloxifene increased lumbar BMD (+8.0% and +2.4% at 12 months, respectively), followed by reductions of urinary NTX level and serum ALP level; however, the effects of alendronate were more pronounced than those of raloxifene. Only raloxifene reduced the serum levels of TC and LDL-C (-3.9% and -7.7% at 12 months, respectively), without any significant effect on the serum HDL-C and TG levels. **Conclusion:** The present study confirmed the efficacy of alendronate greater than raloxifene in increasing lumbar BMD through its effect on marked reduction of the bone turnover more than by raloxifene, and some beneficial effects of raloxifene on lipid metabolism in elderly women with osteoporosis.

Key Words: Alendronate, raloxifene, osteoporosis, postmenopausal women, lipid metabolism

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INTRODUCTION

Osteoporosis most commonly affects postmenopausal women, thus placing them at a significant risk for fractures. Since fractures in the elderly often lead to disability and increase the risk of mortality,^{1,2} appropriate and timely management of osteoporosis is extremely important. Alendronate (ALN) and raloxifene (RAL) have been widely used in the treatment of osteoporosis in postmenopausal women because current evidence, which is strictly based on the principles of evidence-based medicine (EBM), suggests both the short-term and long-term anti-fracture efficacy and safety of ALN and RAL in postmenopausal women with osteoporosis.³⁻⁷

According to the results of randomized controlled trials (RCTs) and meta-analyses of RCTs, ALN and RAL effectively prevent vertebral fractures in postmenopausal women with osteoporosis,^{3,4,8-10} and ALN is also useful for the prevention of nonvertebral and hip fractures.^{3,4} However, because RAL has been shown to be effective in preventing the initial vertebral fracture in postmenopausal osteoporotic women without prevalent vertebral fractures,⁸ it is considered to be the first-line drug in the treatment of younger postmenopausal women with mild osteoporosis or osteopenia with some risk factors for fractures, whereas ALN is primarily considered to be the first-line drug in the treatment of elderly women with osteoporosis who have some risk factors for falls. While no significant differences in the efficacy in terms of the risk reduction of vertebral

fractures have been reported between ALN and RAL, ALN is probably more efficacious than RAL for the prevention of nonvertebral and hip fractures. On the other hand, RAL has been reported to reduce serum cholesterol level in postmenopausal women with osteoporosis.¹¹

Although RCTs have demonstrated a similar incidence of gastrointestinal adverse events in postmenopausal osteoporotic women treated with ALN and placebo,^{9,10} gastrointestinal (GI) adverse events are often encountered in practice during ALN treatment, necessitating discontinuation of the drug. One of the solutions in such cases is to switch from ALN to RAL treatment. However, the efficacy of RAL in elderly women with osteoporosis is not well established, and it remains uncertain whether RAL is safe and effective for reducing the bone turnover, increasing bone mineral density (BMD), and preventing vertebral fractures as ALN in elderly women with osteoporosis. The purpose of this open-labeled prospective study was to compare the effects of ALN and RAL on lumbar BMD, bone turnover, and lipid metabolism, as well as on the incidence of vertebral fractures in elderly women with osteoporosis. In particular, the primary end point was lumbar BMD, and the secondary end point was bone turnover markers.

SUBJECTS AND METHODS

Subjects

One hundred twenty-two postmenopausal women (mean age: 69.4 years) were recruited at Keiyu Orthopaedic Hospital (Gunma, Japan) in September - December 2005. All of them were diagnosed as having osteoporosis according to the Japanese diagnostic criteria.^{12,13} According to the Japanese criteria for the diagnosis of osteoporosis in women, patients with BMD < 70% of the young adult mean (YAM), or of 70 - 80% of the YAM along with a history of osteoporotic fractures, are diagnosed as having osteoporosis. Patients were randomly divided into 2 groups of 61 patients: the ALN (5 mg daily) group and RAL (60 mg daily) group. The doses indicated in the parentheses are the doses mainly used in elderly Japanese women

with osteoporosis, since they have been recognized to be safe and effective.¹⁴⁻¹⁶ The duration of treatment was 12 months. Preliminary screening included medical history, physical examination, plain X-rays of the thoracic and lumbar spine, lumbar BMD measurement, and blood and urinary biochemical tests. Subjects with a history of reflux esophagitis, gastric or duodenal ulcers, or gastrectomy were excluded. Current smokers, and subjects treated with either glucocorticoid, hyperthyroidism, or statins were also excluded. Lumbar BMD was measured, and the assessment of vertebral fractures on the plain X-ray film was performed as described below. The serum levels of calcium, phosphorus, alkaline phosphatase (ALP), total cholesterol (TC), high and low density lipoprotein cholesterol (LDL-C and HDL-C, respectively), and triglycerides (TG) were measured using standard laboratory techniques. The urinary level of cross-linked N-terminal telopeptides of type I collagen (NTX) was measured by enzyme-linked immunosorbent assay. None of the subjects suffered from any metabolic bone diseases, had a history of hormone (estrogen) replacement therapy, or had ever taken medication known to affect bone metabolism prior to the present study. All the subjects were instructed to consume about 800 mg of dietary calcium daily during the study period. Informed consent was obtained from each participant prior to participation in the study. Table 1 illustrates the baseline characteristics of the study subjects, and Table 2 illustrates the serum levels of lipid metabolism markers at baseline. There were no significant differences in any of the baseline characteristics between the 2 groups (as determined by the unpaired t-test). The mean serum levels of TC, TG, LDL-C and HDL-C at baseline were all within the normal ranges. After the start of the treatment, the urinary level of NTX was measured at 3 months, lumbar BMD and serum levels of calcium, phosphorus, ALP, TC, LDL-C, HDL-C, and TG were measured every 6 months, and plain X-rays of the thoracic and lumbar spine were assessed at the end of 12 months of treatment. We compared changes in lumbar BMD, urinary NTX and serum ALP levels, and components of the serum lipid profile between the 2 groups. We also examined the incidence of vertebral fractures. This protocol was

Table 1. Characteristics of Study Subjects

	ALN (n = 61)	RAL (n = 61)
Age (yrs)	70.3 ± 7.6	68.5 ± 7.2
Height (m)	1.48 ± 0.06	1.49 ± 0.06
Body weight (kg)	47.9 ± 6.8	48.4 ± 6.8
Body mass index (kg/m ²)	21.9 ± 2.6	21.7 ± 2.5
Lumbar BMD (g/cm ³)	0.620 ± 0.084	0.647 ± 0.070
%YAM of lumbar BMD (%)	61.4 ± 8.3	64.0 ± 6.9
Serum calcium (mg/dL)	9.4 ± 0.5	9.3 ± 0.4
Serum phosphorus (mg/dL)	3.3 ± 0.6	3.3 ± 0.6
Serum ALP (IU/L)	247 ± 92	249 ± 75
Urinary NTX (nM BCE/mM Cr)	69.3 ± 31.4	71.9 ± 27.2
Number of vertebral fractures	1.59 ± 1.93	1.30 ± 2.04
Percentage of patients with prevalent vertebral fracture	55.7	52.5

Percentage of patients with prevalent vertebral fracture.

Data are expressed as the mean ± SD.

ALN, alendronate group; RAL, raloxifene group; BMD, bone mineral density; YAM, young adult mean; ALP, alkaline phosphatase; NTX, cross linked N-terminal telopeptides of type I collagen.

There were no significant differences in any characteristics between the 2 groups (by the unpaired t-test).

Table 2. Serum Lipid Metabolism Markers at Baseline

	Normal range	ALN (n = 61)	RAL (n = 61)
Total cholesterol (mg/dL)	130 - 219	214 ± 34	209 ± 27
Triglycerides (mg/dL)	30 - 149	139 ± 68	127 ± 58
LDL-cholesterol (mg/dL)	70 - 139	125 ± 29	122 ± 27
HDL-cholesterol (mg/dL)	40 - 90	62 ± 16	61 ± 14

Data are expressed as the mean ± SD.

ALN, alendronate group; RAL, raloxifene group; LDL, low density lipoprotein; HDL, high density lipoprotein.

There were no significant differences in any parameters between the 2 groups (by the unpaired t-test).

approved by the Ethics Committee of Keiyu Orthopaedic Hospital.

Measurement of lumbar BMD

BMD of the lumbar spine (L1-L4) in the anteroposterior view was measured by dual-energy X-ray absorptiometry (DXA) using a Hologic QDR 1500 W apparatus (Bedford, MA, USA). The coefficient of variation (100 × standard deviation/mean) of 5 measurements with repositioning

within 72 hours each time was less than 1.2% in 3 patients.

Assessment of vertebral fractures

Plain lateral X-ray films of the thoracic and lumbar spine were obtained to detect evidence of vertebral fractures. According to the Japanese criteria, a vertebral fracture is defined according to the vertebral height on lateral X-ray films.^{12,13} In brief, the vertebral height was measured at the

anterior (A), central (C), and posterior (P) parts of the vertebral body, and the presence of a vertebral fracture was confirmed when (1) a reduction in the vertebral height was more than 20% (A, C, and P) compared to the height of the adjacent vertebrae, (2) the C/A or C/P was less than 0.8, or the (3) A/P was less than 0.75. The assessment for vertebral fractures was performed at the T4-L4 level.

Statistical analysis

Data were expressed as mean \pm standard deviation (SD) in tables and as mean \pm standard error (SE) in figures. Data were compared between the 2 groups by unpaired t-test. The significance of longitudinal changes in the parameters was determined by one-way analysis of variance (ANOVA) with repeated measures. The incidence of vertebral fractures was compared in the 2 groups by Fisher's exact test. All statistical analyses were performed using the Stat View-J5.0 program on a Windows computer. A significance level of $p < 0.05$ was used for all comparisons.

RESULTS

Adverse events

Eleven patients in the ALN group and 9 patients in the RAL group discontinued treatment during the 12 month period. Table 3 shows the reasons for the dropouts from the study. The main

reasons were epigastric pain, gastric ulcer, and difficulty in compliance in the ALN group, and epigastric pain and difficulty in compliance in the RAL group. No serious adverse events that necessitated hospitalization were observed in either group. Thus, the trial could successfully be completed in 50 (82.0%) patients in the ALN group and 52 (85.2%) patients in the RAL group, and the data from a total of 102 patients were included in the analyses.

Changes in lumbar BMD, serum calcium and phosphorus, and bone turnover markers

Fig. 1 and 2 show longitudinal changes in lumbar BMD, serum levels of calcium and phosphorus, and levels of the bone turnover markers. A significant reduction in urinary NTX level was observed in both groups (both $p < 0.0001$ by one-way ANOVA with repeated measures). However, there was a significant difference in the percent decrease in the urinary NTX level between the 2 groups (44.6% in the ALN group and 34.5% in the RAL group, $p < 0.05$ by the unpaired t-test). Significant increases in lumbar BMD and significant decreases in the serum calcium and ALP levels were observed in both groups ($p < 0.01$, $p < 0.001$, and $p < 0.0001$, respectively, by one-way ANOVA with repeated measures). There was a significant difference in the percent decrease in the serum ALP level at 6 months between the 2 groups (-14.1% in the ALN group and -5.0% in the RAL group, $p < 0.05$ by the unpaired t-test). There was also a significant difference in the

Table 3. Reasons for Drop Out of the Study

ALN (n = 11)	RAL (n = 9)
Epigastric pain (n = 3)	Epigastric pain (n = 4)
Difficulty in compliance (n = 3)	Difficulty in compliance (n = 3)
Gastric ulcer (n = 1)	Liver dysfunction (n = 1)
Heartburn (n = 1)	Urticaria (n = 1)
Liver dysfunction (n = 1)	
Diarrhea (n = 1)	
Constipation (n = 1)	

Eleven patients in the ALN (alendronate) group and 9 patients in the RAL (raloxifene) group dropped out of the study because of the above reasons.

Namely, 82.0% and 85.2% of patients in the respective group completed the trial.

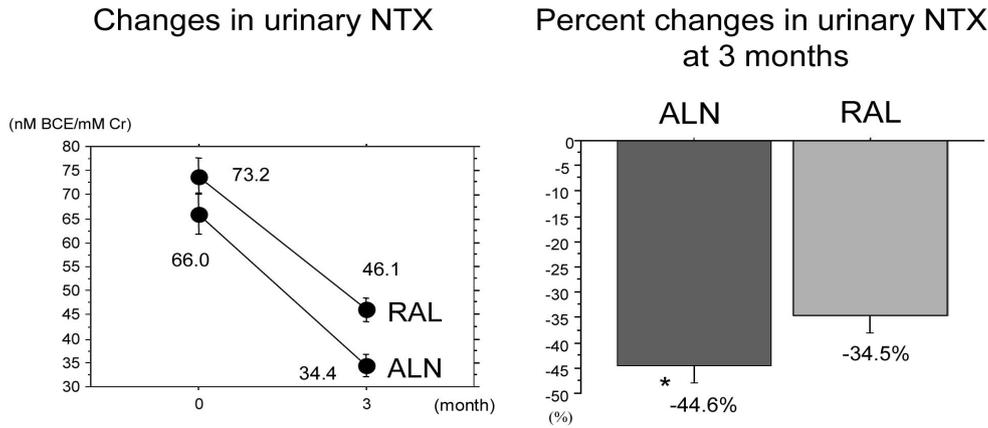


Fig. 1. Changes in urinary NTX. Data are expressed as the mean \pm SE. One-way ANOVA with repeated measurements was used to examine the significance of the longitudinal changes in the urinary NTX level. The unpaired t-test was used to compare the percent changes in the urinary NTX level between the 2 groups. A significant reduction of the urinary NTX level was observed in the both groups (both $p < 0.0001$ by the one-way ANOVA with repeated measurements). However, there was a significant difference in the percent decrease in the urinary NTX level between the 2 groups (44.6% for the ALN group and 34.5% for the RAL group, $p < 0.05$ by the unpaired t-test). * $p < 0.05$ vs. RAL. ALN, alendronate (n = 50); RAL, raloxifene (n = 52); NTX, cross linked N-terminal telopeptides of type I collagen.

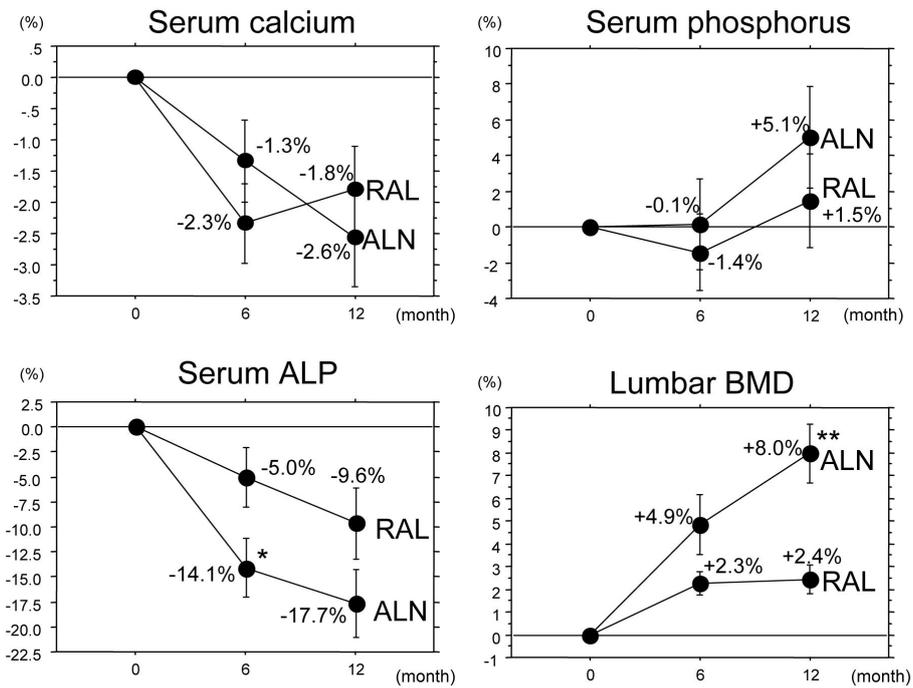


Fig. 2. Percent changes in serum biochemical markers and lumbar BMD. Data are expressed as the mean \pm SE. One-way ANOVA with repeated measurements was used to examine the significance of the longitudinal changes in biochemical markers and the lumbar BMD. A significant increase in the lumbar BMD and significant decreases in the serum calcium and ALP levels were observed in the both groups ($p < 0.01$, $p < 0.001$, and $p < 0.0001$, respectively, by the one-way ANOVA with repeated measurements). There was a significant difference in the percent decrease in the serum ALP level at 6 months between the 2 groups (-14.1% for the ALN group and -5.0% for the RAL group, $p < 0.05$ by the unpaired t-test). There also was a significant difference in the percent increase in the lumbar BMD at 12 months between the 2 groups (+8.0% for the ALN group and +2.4% for the RAL group, $p < 0.01$ by the unpaired t-test). * $p < 0.05$ vs. RAL, ** $p < 0.01$ vs. RAL. ALN, alendronate (n = 50); RAL, raloxifene (n = 52); BMD, bone mineral density; ALP, alkaline phosphatase.

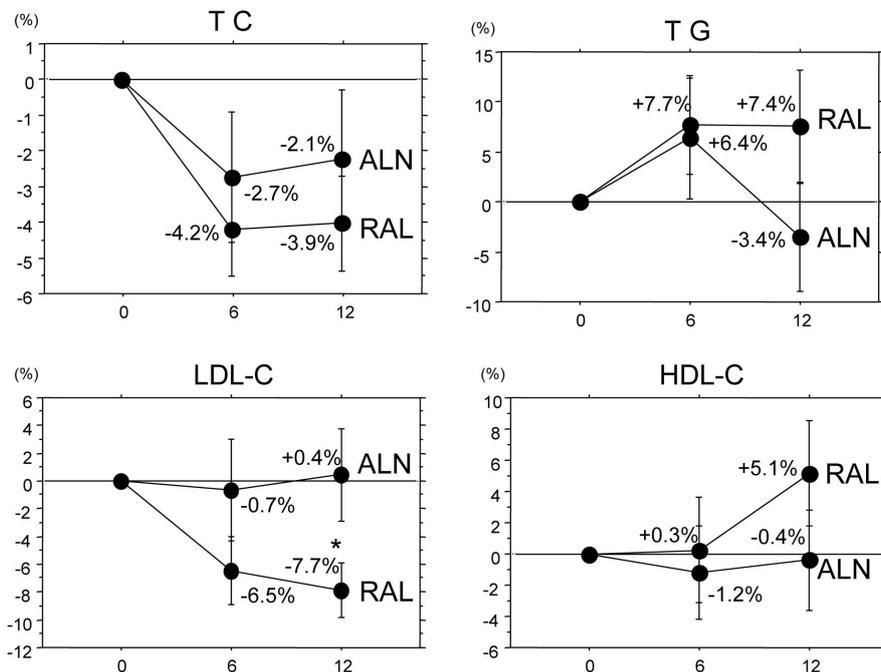


Fig. 3. Percent changes in serum lipid metabolism markers. Data are expressed as the mean \pm SE. One-way ANOVA with repeated measurements was used to examine the significance of the longitudinal changes in the serum lipid metabolism markers. Significant decreases in the serum TC and LDL-C levels were observed in the RAL groups ($p < 0.01$ and $p < 0.001$, respectively, by the one-way ANOVA with repeated measurements). However, no significant changes in any serum lipid markers were observed in the ALN group (by the one-way ANOVA with repeated measurements). There was a significant difference in the percent decrease in the serum LDL-C level at 12 months between the 2 groups (+0.4% for the ALN group and -7.7% for the RAL group, $p < 0.05$ by the unpaired t-test). * $p < 0.05$ vs. ALN. ALN, alendronate ($n = 50$); RAL, raloxifene ($n = 52$); TC, total cholesterol; TG, triglycerides; LDL, low density lipoprotein; HDL, high density lipoprotein.

percent increase in the lumbar BMD at 12 months between the 2 groups (+8.0% in the ALN group and +2.4% in the RAL group, $p < 0.01$ by the unpaired t-test).

Changes in the components of the serum lipid profile

Fig. 3 shows longitudinal changes in the serum TC, LDL-C, HDL-C, and TG levels in the 2 groups. Significant decreases in the serum TC and LDL-C levels were observed in the RAL group ($p < 0.01$ and $p < 0.001$, respectively, by one-way ANOVA with repeated measures). However, no significant changes in any of the components of the serum lipid profile were observed in the ALN group (by one-way ANOVA with repeated measures). There was a significant difference in the percent decrease in the serum LDL-C level at 12 months between the 2 groups (+0.4% in the ALN group

and -7.7% in the RAL group, $p < 0.05$ by the unpaired t-test). The percent decrease in the serum TC level at 12 months, relative to the baseline in the RAL group was 3.9%.

Incidence of vertebral fractures

After 12 months of treatment, the incidence of vertebral fractures was 14.0% in the ALN group and 13.1% in the RAL group, whereas no significant difference in the incidence of vertebral fractures was observed between the 2 groups.

DISCUSSION

The present study showed that treatment with both ALN and RAL increased lumbar BMD (+8.0% and +2.4% at 12 months, respectively), followed by reductions of the urinary NTX level

(-44.6% and -34.5% at 3 months, respectively) and serum ALP level (-17.7% and -9.6% at 12 months, respectively). However, the effects of ALN were more pronounced than those of RAL. Only RAL reduced the serum TC and LDL-C levels (-3.9% and -7.7% at 12 months, respectively). Thus, we confirmed the greater efficacy of ALN than RAL in increasing lumbar BMD through its effect to reduce the bone turnover more markedly than by RAL and some beneficial effects of RAL on the lipid metabolism in elderly women with osteoporosis. However, the incidence of vertebral fractures was similar in the 2 groups (14.0% in the ALN group and 13.1% in the RAL group).

According to previous reports on the effects of ALN and RAL on lumbar BMD and bone turnover markers in Japanese postmenopausal women with osteoporosis (mean ages: 63-65 years), ALN decreases the urinary deoxypyridinoline level by about 38% at 3 months and increases lumbar BMD by 6.21% at 1 year,¹⁴ while RAL decreases the urinary NTX level by about 26% at 3 months and increases lumbar BMD by 3.5% at 1 year.¹⁶ Previously, the Efficacy of Fosamax versus Evista Comparison Trial (EFFECT), conducted to compare the effects of ALN and RAL on BMD in postmenopausal women with low BMD (mean age, 62 years), revealed that the improvements in BMD and markers of bone turnover were substantially greater during treatment with ALN than with RAL.¹⁷ Thus, the effects of ALN on lumbar BMD and bone turnover in younger postmenopausal women with osteoporosis appear to be more pronounced than those of RAL. However, a direct comparison of the efficacy of ALN and RAL in elderly women with osteoporosis in a single study has rarely been reported. The effects of ALN and RAL on lumbar BMD in the present study (mean age: 69.4 years) appear to be consistent with previous results (mean ages: 63-66 years).¹⁴⁻¹⁶

The difference in the efficacy of the 2 drugs in increasing lumbar BMD might be attributed to the greater efficacy of ALN in reducing bone turnover than that of RAL. The greater the suppression of bone turnover, the greater the increase in lumbar BMD.¹⁸⁻²¹ The bisphosphonates inhibit osteoclast-mediated bone resorption, and loss of osteoclast function and apoptosis is the consequence of loss of function of one or more important signaling

proteins. In particular, nitrogen-containing bisphosphonates like ALN are not metabolized, but can inhibit enzymes of the mevalonate pathway, thereby preventing the biosynthesis of isoprenoid compounds, which are essential for post-translational modification of small GTPases.²² On the other hand, RAL is a nonsteroidal benzothiophene that binds to estrogen receptors and inhibits bone resorption without stimulating the uterine endometrium in postmenopausal women.¹¹ Thus, the mechanism of inhibition of bone resorption and, consequently, the degree of anti-resorptive effect may differ between ALN and RAL. In the present study, the RAL group showed less pronounced reductions in bone turnover markers than the ALN group, consistent with previous results.

Additional studies showed that the incidence of vertebral fractures during a 1-year treatment period with ALN in Japanese postmenopausal women with osteoporosis (mean age: 71-73 years) is 2% to 3%,¹⁵ and that the incidence during a 1-year treatment period with RAL in Asian postmenopausal women with osteoporosis (mean age: 64-66 years) is 0%.²³ Recently, the Evista ALN comparison (EVA) trial was conducted to compare the anti-fracture efficacy of ALN and RAL; however, this study could not be completed because of inability to collect a sufficient number of study subjects.²⁴ Based on the prevalence of vertebral fractures at baseline, our subjects might have had more severe osteoporosis than those in previous studies, and the incidence of vertebral fractures was higher in the present study than that reported in previous studies.^{15,23} Despite the difference in the efficacy on lumbar BMD, the anti-fracture efficacy in our subjects against vertebral fractures was similar in ALN and RAL, although the present study might not have sufficient power to allow a conclusion on the drugs' effect on vertebral fractures.

It has recently been established that the anti-fracture efficacy of anti-resorptive drugs cannot be explained simply by alterations of BMD, and that there is in fact, overall improvement of the bone quality in postmenopausal women with osteoporosis, when treated with these drugs.^{25,26} Bone strength reflects both bone mass and bone quality, and bone quality is derived from bone architecture, turnover, damage accumulation, mineraliza-

tion, and matrix.²⁷ Clinically, the effects of the above mentioned drugs on bone quality have not yet been clearly established. However, the incidence of fractures could be considered as an index of bone quality, because reduction of the fracture risk is considered to be the most convincing evidence of the improved bone quality. In particular, the reduction of the levels of bone turnover markers to their respective normal ranges has been reported to be important for reducing the incidence of vertebral and non-vertebral fractures in postmenopausal women with osteoporosis.^{25,26} In the present study, both ALN and RAL reduced the urinary NTX level to the normal range for Japanese women (9.3 - 54.3 nmol BCE/mmol Cr),²⁸ and the incidence of vertebral fractures was similar in the 2 groups. The increase of lumbar BMD was smaller in the RAL group than in the ALN group, suggesting that RAL might have a more significant effect on bone quality than on BMD.

Eleven patients (18.0%) in the ALN group dropped out of the study, and the main reasons for the dropouts were gastric problems and difficulty in compliance. GI adverse symptoms are considered to be the most significant adverse effects of ALN even though RCTs have reported no statistically significant difference in the incidence of GI adverse events between postmenopausal women with osteoporosis treated with ALN and placebo.^{9,10} Cryer and Bauer²⁹ have argued that upper GI adverse events reported during treatment with bisphosphonates may reflect high background incidence of upper GI complaints, and that RCTs, which represent the highest level of evidence, suggest little or no increase in the risk of upper GI problems with bisphosphonates, provided that they were administered properly. It has been suggested that increased sensitivity to detect upper GI symptoms in elderly women with osteoporosis is more likely than the existence of a causal relationship between upper GI symptoms and ALN.

On the other hand, 9 patients (14.8%) in the RAL group dropped out of the study, and the main reasons for the dropouts were also gastric problems and difficulty in compliance. The main adverse effects of RAL reported from the Multiple Outcomes of RAL Evaluation (MORE) study

include hot flashes, leg cramps, and deep vein thrombosis (DVT).⁸ However, it was shown in 1 study conducted, on Asian postmenopausal women with osteoporosis that the incidence of these complications did not differ significantly between the RAL and placebo groups.³⁰ It is likely that race, that is, Caucasian or Asian, may influence the incidence of DVT. Adverse events like gastric problems have rarely been reported. However, in the present study, the above mentioned adverse events were not observed while GI problems were frequently observed. Thus, attention should be paid to such adverse events during the treatment with RAL. It has been reported that the risk of invasive breast cancer is reduced in postmenopausal women with osteoporosis when treated with RAL,³¹ which could be important for pharmacoeconomy and long-term adherence to treatment. Thus, providing such information to patients might lead to improvement of adherence with RAL treatment.

It is known that RAL reduces serum levels of TC, LDL-C, and TG in postmenopausal women with osteoporosis.¹¹ In Japanese postmenopausal women with osteoporosis, RAL has been reported to decrease serum levels of TC and LDL-C by about 7% and 11%, respectively.¹⁶ In the present study also, serum levels of TC and LDL-C in the RAL group decreased (3.9% and 7.7%, respectively). Because serum TG level can strongly be affected by food intake, no significant change in this parameter was probably observed after RAL treatment. The degree of reduction of serum TC and LDL-C levels was quite small, therefore, it remains uncertain if such small reductions help prevent coronary heart disease (CHD) in these patients. One study reported that while RAL reduced the incidence of clinical vertebral fractures, it did not significantly affect the risk of CHD in postmenopausal women with CHD or multiple risk factors for CHD.³² Thus, the benefits of RAL treatment in reducing vertebral fractures should carefully be weighed against the increased risk of DVT and fatal stroke associated with the administration of this drug.³² Further studies are needed to confirm the beneficial effects of RAL in the prevention of CHD in Japanese postmenopausal women with osteoporosis and CHD or risk factors for CHD.

There are some notable limitations of this study. First, the study was not a double-blind trial but an open-labeled study. Therefore, some of the results might be biased. Second, the number of study subjects was relatively small and not large enough to lend sufficient power to the results. Double-blind randomized placebo-controlled studies conducted on a sufficient number of subjects are needed to confirm the present results. Third, despite the fact that serum levels of calcium and phosphorus could be affected by seasonal variations of vitamin D, serum levels of 25-hydroxyvitamin D were not assessed in the present study. Thus, further studies are needed to clarify the influence of ALN or RAL treatment as well as seasonal variations of vitamin D on calcium and phosphorus metabolism.

In conclusion, the present head-to-head trial showed that treatment of elderly women with osteoporosis with both ALN and RAL increased lumbar BMD followed by reduction of bone turnover; however, the effects of ALN were more pronounced than those of RAL, and only RAL reduced serum levels of TC and LDL-C. Thus, ALN increased lumbar BMD with greater efficacy than RAL in elderly women with osteoporosis through marked reduction of bone turnover. On the other hand, RAL appeared to have some beneficial effects on lipid metabolism in subjects.

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