Alendronate improves QOL of postmenopausal women with osteoporosis

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Purpose: Postmenopausal osteoporosis causes bone fracture as well as pain, physical, psychological and socially adverse effects, which affects a patient’s quality of life (QOL). The effect of alendronate on QOL was investigated compared with that of alfalcacidol in postmenopausal osteoporotic women.

Patients and methods: A total of 44 postmenopausal osteoporotic women (mean age 69.8 years) with back or joint pain, although capable of walking, were randomly assigned to two groups; group A (n = 25) received 5 mg/day of alendronate, and group B (n = 19) received 0.5 µg/day of alfalcacidol, for the first 4 months. For the following 2 months, the group A received 0.5 µg/day of alfalcacidol and the group B received 5 mg/day of alendronate in a crossover design. The patient’s QOL was evaluated by score of Japanese Osteoporosis Quality of Life Questionnaire (JOQOL), and pain intensity using a visual analog scale (VAS). Bone metabolism was measured by bone mineral density (BMD) and a biomarker for bone resorption, urinary crosslinked N-terminal telopeptide of type I collagen (NTX).

Results: With 4-month treatment, alendronate, but not alfalcacidol, improved pain-related QOL, reduced joint pain by VAS, and increased bone mineral density. Both treatments significantly reduced bone resorption, the inhibition was significantly higher with alendronate (−56.5%) compared with alfalcacidol (−18.1%). After crossover, the patients in group A received alfalcacidol and had a reduced total and daily living activity-related QOL scores, and increased upper back pain by VAS. The group B received alendronate had significantly reduced bone resorption after the 2 months.

Conclusion: Alendronate improves the QOL of Japanese postmenopausal women with osteoporosis by reducing pain intensity as well as increasing bone mineral density.

Keywords: osteoporosis, bisphosphonates, quality of life, pain, vitamin D

Introduction
Patients affected by age-related diseases have been increasing in recent years as the numbers of our elderly population has been increasing. This is especially so for the condition of postmenopausal osteoporosis which frequently causes impaired the physical, psychological and social life of the patients due to bone fractures or pain; in addition it also an added health care burden to society.1–6 Thus, it is important to find osteoporosis treatment which can maintain or improve a patient’s quality of life (QOL) as well as prevent bone fracture. Bisphosphonates have been developed as osteoporosis drugs which improve pain in lower back as well as QOL in the patients suffering this condition to increase bone mass by inhibiting bone resorption and by preventing bone fracture.7,8 This is especially so for alendronate which reduces pain and improves QOL more effectively, than compared to calcium monotherapy, in post menopausal women.
in osteoporosis. However, the effect of bisphosphonates on improving QOL in osteoporotic patients has not been reported in a randomized controlled study in Japan to date. In the present study, we examined the effect of alendronate on QOL and pain in postmenopausal Japanese women with osteoporosis using a randomized comparative crossover design. Alfacalcidol was used as a comparative drug, as it has been reported to reduce the low back pain in an earlier double-blind study in Japan.10

**Materials and methods**

**Study design**

This is a randomized comparative study conducted in postmenopausal women with osteoporosis who had been recruited in the outpatient clinics of 10 medical institutions within the Fukuoka prefecture, Japan, who were suffering pain in the lower back, the upper back or joints, although they were capable of walking. Osteoporosis was defined by criteria given by the Japanese Society for Bone and Mineral Research as; less than 70% of bone mineral density of the young adult mean (T-score < -2.5). The patients were excluded if they had osteomalacia, renal dysfunction (serum creatinine > 1.5 mg/dL), malignant tumor, insulin therapy and bisphosphonates therapy within 6 months. The study prohibited the use of drugs which might affect bone metabolism such as calcitonin, ipriflavone, vitamin K, and estrogen products. Patients who had been taking anti-inflammatory drugs, including patches and cream did not change either the drug and/or the dosage postregistration. The patients who initially required long-term treatment with anti-inflammatory drugs were excluded. At the baseline, patients were interviewed for family history of osteoporosis, pain and QOL assessment. X-rays of the lumbar vertebrae were taken to examine the presence of bone fracture.

A total of 44 registered patients were centrally randomized into two groups; group A (n = 25) receiving 5 mg/day of alendronate for the first 4 months and 0.5 μg/day of alfacalcidol for the following 2 months, and group B (n = 19) receiving 0.5 μg/day of alfacalcidol for the first 4 months and 5 mg/day of alendronate for the following 2 months as shown in Figure 1. The data of 10 patients were excluded from the analysis as; 4 patients did not have QOL data and 3 patients

**Figure 1** Enrollment and outcomes.

**Abbreviation:** JOQOL, Japanese Osteoporosis Quality of Life Questionnaire.
were lost in the follow-up of group A, and 3 patients were lost in the follow-up of group B. The data of 34 patients, 18 patients in the group A and 16 patients in the group B, were analyzed in the present study for the first 4 months. A total of 13 patients in the group A and 10 patients in the group B who completed the additional 2 months study after the crossover, were included for analysis.

The differences in QOL and pain were evaluated between alendronate treatment and alfacalcidol treatment with the following methods.

For the primary endpoint, a change in patient QOL, the QOL was assessed by Japanese Osteoporosis Quality of Life Questionnaire (JOQOL) consisting with 38 questions in six categories (pain, daily living activity, recreational and social activities, general health conditions, posture and figure, falls and the psychological effects pertaining to the condition) at the baseline, at 4 and 6 months. Patient response to each question was scored using a points scale from 0 to 4; giving 4 points at maximum. The six categories included areas related to: “pain” (5 questions with total of 20 points); “daily living activity” (16 questions with 64 points); “recreational and social activities” (5 questions with 20 points); “general health condition” (3 questions with 12 points); “posture and figure” (4 questions with 16 points); and “fall and its psychological effects” (5 questions with 20 points); with total of 152 points. The higher score indicated a higher QOL.

Pain was also assessed by visual analog scale (VAS) of 10 points at the baseline, 4 and 6 months for pain in the upper back, the lower back and the joints. Bone mineral density of lumbar vertebrae was measured by dual X-ray absorptiometry (DXA) at the baseline and 4 months. It was measured at Kyushu University and Fukuoka Teishin Hospital with the same measuring devices, QDR_4500 (Hologic, Tokyo, Japan). Bone resorption was measured by the marker, urinary cross-linked N-terminal telopeptide of type I collagen (NTX) at the baseline then at 4 and 6 months. All biochemical markers were measured centrally at SRL (Special Reference Laboratories, Tokyo, Japan). The observation period after the crossover was limited to 2 months for ethical reasons, since exacerbation of the clinical condition was previously observed in the patients who had switched from alendronate to alfacalcidol.

Statistical analysis
We focused on improvements on the pain score in estimating the required sample size in each group. Because of a lack of information about expected improvement in the pain score and its variation, we calculated the sample sizes under different conditions with a two-sided significance level of 0.05 and 80% power. We also assumed that the standard deviation (SD) for improvements was 5 points. When the improvements in the pain score were 3, 4 or 5 points by the alendronate treatment, the required sample sizes were estimated to be 22, 13 and 8, respectively.

The values were expressed as mean ± SD. The differences in baseline characteristics among groups were evaluated by a Chi-square test, Student’s T-test, or ANOVA, followed by Tukey test. The differences in scores between the two groups were evaluated by Mann–Whitney U test. The differences in percent change of bone marrow density (BMD) or NTX within the same group was evaluated between the baseline and that of 4 months or 6 months with ANOVA followed by Tukey test. The difference with \( P < 0.05 \) was considered to be significant.

All statistical calculations were performed with SPSS (SPSS Inc., Chicago, IL, USA), and/or Statistica (StatSoft, Tulsa, OK, USA) computer software.

Results
The baseline characteristics of 34 patients who completed the first 4 months of treatment were compared between the two groups as shown in Table 1. No significant differences in age, BMD, or the incidence of lumbar vertebral fracture were observed between the two groups. Pain intensity using the VAS in joints (4.2 ± 2.0 versus 2.7 ± 1.8) and QOL impairment in “recreational and social activities” were significantly higher in the group A (alendronate) and the number of patients with a family history of osteoporosis were significantly higher in the group B (alfacalcidol).

During the first 4-month treatment, the patient QOL according to the total QOL score indicated a tendency to improve with both alendronate and alfacalcidol. Although alfacalcidol significantly improved the total QOL score, the average changes were similar between the two treatments (Figure 2). Furthermore, the pain related QOL was significantly improved by alendronate, but not by alfacalcidol, according to the QOL scores of six categories.

Based on VAS, the pain intensity of joints was significantly reduced by alendronate, while the intensity did not significantly change in any regions by alfacalcidol (Figure 3).

Although a tendency of increased BMD of the lumbar vertebrae was observed in both groups, only the treatment with alendronate significantly increased the BMD from the baseline with the 4-month alendronate treatment (0.637 ± 0.149 versus 0.659 ± 0.159, \( P < 0.001 \)) (Figure 4a). Furthermore, both alendronate and alfacalcidol reduced bone resorption as measured by urinary NTX. Alendronate significantly
Table 1 Baseline patient characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group A (n = 18) alendronate</th>
<th>Group B (n = 16) alfacalcidol</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>66.7 ± 9.1</td>
<td>72.7 ± 8.1</td>
<td>ns</td>
</tr>
<tr>
<td>BMD Lumbar vertebrae (g/cm²)</td>
<td>0.637 ± 0.149</td>
<td>0.628 ± 0.137</td>
<td>ns</td>
</tr>
<tr>
<td>Urinary NTX (nM BCE/nM Cr)</td>
<td>56.4 ± 25.4</td>
<td>53.0 ± 23.4</td>
<td>ns</td>
</tr>
<tr>
<td>Vertebral fractures at baseline (yes/no)</td>
<td>4/13</td>
<td>4/12</td>
<td>ns</td>
</tr>
<tr>
<td>Family history of osteoporosis (yes/no)</td>
<td>3/15</td>
<td>9/7</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>VAS (lower back)</td>
<td>4.8 ± 2.4</td>
<td>3.3 ± 1.7</td>
<td>ns</td>
</tr>
<tr>
<td>VAS (upper back)</td>
<td>3.1 ± 2.1</td>
<td>3.1 ± 2.3</td>
<td>ns</td>
</tr>
<tr>
<td>VAS (joints)</td>
<td>4.2 ± 2.0</td>
<td>2.7 ± 1.8</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

JOQOL

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group A (n = 18) alendronate</th>
<th>Group B (n = 16) alfacalcidol</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain (20 points)</td>
<td>12.3 ± 4.3</td>
<td>13.5 ± 4.0</td>
<td>ns</td>
</tr>
<tr>
<td>Activity of daily living (64 points)</td>
<td>58.1 ± 8.0</td>
<td>56.8 ± 10.4</td>
<td>ns</td>
</tr>
<tr>
<td>Recreational and social activities (20 points)</td>
<td>11.6 ± 4.9</td>
<td>8.3 ± 4.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>General health (12 points)</td>
<td>7.5 ± 3.3</td>
<td>7.1 ± 3.2</td>
<td>ns</td>
</tr>
<tr>
<td>Posture and figure (16 points)</td>
<td>10.0 ± 4.4</td>
<td>9.6 ± 2.3</td>
<td>ns</td>
</tr>
<tr>
<td>Falls and the psychological effects (20 points)</td>
<td>12.8 ± 3.8</td>
<td>11.8 ± 3.6</td>
<td>ns</td>
</tr>
<tr>
<td>Total QOL score (152 points)</td>
<td>73.3 ± 12.3</td>
<td>70.4 ± 10.0</td>
<td>ns</td>
</tr>
</tbody>
</table>

Abbreviations: NS, not significant; QOL, quality of life; VAS, visual analog scale; JOQOL, Japanese Osteoporosis Quality of Life Questionnaire; BMD, bone mineral density; NTX, urinary crosslinked N-terminal telopeptide of type I collagen, BCE, bone collagen-equivalent; Cr, creatinine.

Figure 2 Comparison of JOQOL score changes in pain, recreational and social activity, daily living activity, general health, posture and figure, fall and psychological effects and total between alendronate and alfacalcidol treatments during the first 4 months. Increased score indicates improvement of QOL.

Note: *P < 0.05, **P < 0.01 vs baseline.

Abbreviation: JOQOL, Japanese Osteoporosis Quality of Life Questionnaire; QOL, quality of life.
suppressed the bone resorption more than alfacalcidol (−57% versus −18%, P < 0.001) as shown in Figure 4b.

Crossover
After the first 4-month treatment, the patients were followed for 2 months after the crossover to the other drug. A total of 13 patients in the group A received alfacalcidol and 10 patients in the group B received alendronate. The two groups had similar patient characteristics (except age) at the end of the first 4-month treatment. Mean age was significantly lower in the group A than in the group B (age 65.9 ± 8.8 years versus 73.6 ± 5.1 years, P < 0.05) as shown in Table 2.

Figure 3 Comparison of pain intensity reduction between alendronate and alfacalcidol treatments during the first 4 months according to visual analog scale of 10 points. Pain was assessed in lower back, upper back and joints.

Note: *P < 0.05 vs baseline.

Figure 4 Comparison of percent changes in BMD of lumbar vertebrae A) and urinary NTX B) between alendronate and alfacalcidol treatments during the first 4 months of the treatments.

Abbreviations: BMD, bone mineral density; NTX, urinary crosslinked N-terminal telopeptide of type I collagen.
During the 2 months after the crossover, the total QOL scores and the daily living activity related QOL score were decreased in the group A that had switched from alendronate to alfacalcidol. No significant changes were observed in total, and “posture and figure” related QOL in the group B which switched from alfacalcidol to alendronate. However, total QOL and posture and figure related QOL increased significantly in the group B taking alendronate than compared with group A, now taking alfacalcidol, during the 2 month post-crossover period. This suggests that alendronate suppressed any decrease in QOL in group B, as shown in Figure 5.

According to pain intensity evaluated by VAS, group A had significantly increased upper back pain when taking alfacalcidol in the 2-month post-crossover period, while group B had no significant change in pain intensity with alendronate in any of the studied regions. No significant difference was observed in pain intensity changes between the two groups (Figure 6). These results suggest that switching to alfacalcidol from alendronate caused a decrease in QOL and increased pain.

Bone resorption measured by NTX was significantly increased in group A, which switched to alfacalcidol during the 2 month post-crossover period, (20.3 ± 6.2 to 28.4 ± 9.1 nM bone collagen-equivalent [BCE]/nM creatinine [Cr]), while NTX was significantly decreased in the group B that switched to alendronate. This suggests that alendronate significantly suppresses the bone resorption more than alfacalcidol (P < 0.01) as shown in Figure 7.

### Discussion

The present study demonstrated that alendronate improved the QOL, especially pain related QOL, in postmenopausal osteoporotic Japanese women. The improvement in pain related QOL by alendronate was supported by the VAS pain intensity measurement; alendronate significantly reduced pain in the joints, and reduced any exacerbation of pain in the back, suggesting that pain reduction by alendronate contributed to the improvement of overall QOL in the patients.

The JOQOL questionnaire was created by the Japanese Society for Bone and Mineral Research to evaluate the QOL of Japanese osteoporotic patients based on the Osteoporosis Assessment Questionnaire in USA and the Questionnaire for Quality of Life by European Foundation for Osteoporosis (Qualeffo-42). It is a modification of the two questionnaires with additional questions that are suitable to the life style of Japanese women. According to the paper by Takahashi and colleagues, the JOQOL scores are correlated to the scores of Medical Outcomes Study Short Form 36 (SF-36) with coefficient r = 0.78 and reproducibility (r = 0.92).11

Although total QOL scores showed an increased trend with both alendronate and alfacalcidol in the first 4 months,

| Table 2 Patient baseline characteristics after crossover |
|---------------------------------|------------------|------------------|---|
| **Characteristic**              | **Group A (n = 18) alendronate** | **Group B (n = 16) alfacalcidol** | **P value** |
| Age (year)                      | 66.7 ± 9.1       | 73.6 ± 5.1       | <0.05 |
| BMD Lumbar vertebrae (g/cm²)    | 0.639 ± 0.147    | 0.613 ± 0.164    | ns |
| Urinary NTX (nmol BCE/nmol Cr)  | 49.0 ± 10.8      | 49.2 ± 23.6      | ns |
| Vertebral fractures at baseline (yes/no) | 3/9            | 2/8              | ns |
| Family history of osteoporosis (yes/no) | 2/11           | 5/5              | ns |
| VAS (lower back)                | 5.0 ± 2.8        | 3.8 ± 1.4        | ns |
| VAS (upper back)                | 3.3 ± 2.3        | 3.3 ± 2.4        | ns |
| VAS (joints)                    | 4.2 ± 2.1        | 2.5 ± 1.7        | ns |
| JOQOL                           |                  |                  |     |
| Pain (20 points)                | 11.4 ± 4.7       | 13.8 ± 4.1       | ns |
| Activity of daily living (64 points) | 57.2 ± 8.9     | 55.0 ± 12.7      | ns |
| Recreational and social activities (20 points) | 11.6 ± 4.8    | 7.9 ± 5.0        | ns |
| General health (12 points)      | 7.3 ± 3.9        | 7.5 ± 3.4        | ns |
| Posture and figure (16 points)  | 11.5 ± 4.0       | 9.9 ± 2.8        | ns |
| Falls and the psychological effects (20 points) | 12.8 ± 4.3 | 11.3 ± 4.2       | ns |
| Total QOL score (152 points)    | 72.8 ± 13.8      | 69.3 ± 11.6      | ns |

**Abbreviations:** NS, not significant; QOL, quality of life; VAS, visual analog scale; JOQOL, Japanese Osteoporosis Quality of Life Questionnaire; BMD, bone mineral density; NTX, urinary crosslinked N-terminal telopeptide of type I collagen; BCE, bone collagen-equivalent; Cr, creatinine.
the significant improvement of the total QOL was found only with alfacalcidol in the present study. However, among the QOL of six categories, alendronate significantly improved pain related QOL. In several previous studies, QOL improvement and pain reduction occurred with alendronate. Nevitt and colleagues demonstrated in a large scale 3-year randomized double blind study that alendronate reduced the number of days disability spent in bed, and the days of...
limited activities caused by low back pain. Moreover, Dur- 
sun and colleagues showed that alendronate and calcitonin 
reduced pain and improved the QOL equally after 6-months 
of treatment, when alendronate, calcitonin and calcium were 
compared for pain reduction, when assessed by VAS and 
QOL improvement, as evaluated by the Nottingham Health 
Profile in an open-labeled study.

The mechanism alendronate improves pain has not been 
clarified. The reduced incidence of bone fracture by alen-
donate was suggested to reduce the pain. However in our 
study no new fractures were observed during the study period 
and the effect of alendronate on reducing pain appeared 
relatively quickly after the commencement of treatment. A marker for bone resorption, NTX, was decreased more 
with alendronate than with alfacalcidol. Although markers 
for bone metabolism and pain or QOL were not significantly 
associated in such a small scale study as ours, NTX reduc-
tion was positively associated with low back pain in 80 post 
menopausal women with osteoporosis reported by Iwamoto 
and colleagues. In patients with bone metastases or multiple 
myeloma, an intravenous treatment of bisphosphonates was 
shown to relieve skeletal pain within several weeks of the 
commencement of treatment. The timing for onset of 
the positive effects of the drug suggests that the effects of 
bisphosphonates on bone pain may not be explicitly related 
to an anti-osteoporotic effect, and likely to be associated with 
another mechanism of pain reduction.

Within the local bone lesions, elevated inflammatory 
cytokines, prostaglandin and growth factors stimulate 
osteoclast activity and nociceptors to cause bone pain. Since bisphosphonates were shown to reduce osteoclas-
togenic cytokines, this may explain the pain relieving 
effect. However, osteoclasts are known to degrade bone 
minerals by secreting protons through the vacuolar H^+-
ATPase, creating acidic microenvironments. Nagae 
and colleagues proposed that osteoclasts plays an 
important role in producing bone pain by creating acidosis 
and through activating acid-sensing receptors of sensory 
neurons. In the study, bisphosphonates suppressed inflam-
matory hyperalgesia by inhibiting the effect of osteoclasts 
in the animal model.

There are limitations in the present study. The number of 
study patients is small and some baseline patient characteris-
tics were different between the groups; group A had a lower 
number of patients with a family history of osteoporosis and 
a slightly lower QOL in recreational and social activities 
when compared with the group B. This study was carried 
out as an open label study. There may be bias in the effect of 
the drugs. To confirm the results, a large double blind study 
must be conducted.
Conclusions
Alendronate significantly suppressed pain when measured by a VAS, and by patient QOL measured by JOQOL, in postmenopausal osteoporotic patients. The efficacy of alendronate is higher than that of alfacalcidol. The long term treatment of osteoporosis with alendronate not only prevents bone fracture, but also improves the patient’s QOL and reduces pain or prevents the exacerbation of pain.

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Disclosures
The authors report no conflicts of interest relevant to this work.

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