Hip fracture prevention in the nursing home should involve measures to increase bone density, prevent falls, and protect the hip. The introduction of once weekly dosing of alendronate and risedronate is expected to increase the utilization of such therapies in the nursing home. The recent approval of parathyroid hormone therapy adds a new powerful medication that may help nursing home patients with severe osteoporosis. (Annals of Long-Term Care: Clinical Care and Aging 2003;11[3]:25-32)

INTRODUCTION

More than 300,000 hip fractures occur in the United States each year.1 Hip fracture is linked to increased mortality and morbidity among older individuals. Twenty percent to 30% of patients with hip fractures are expected to die within a year, with most of the deaths occurring within the first six months after the fracture.2-3 Among survivors, 30-50% will never regain their prefracture functional status.4 In one report, 15-20% of individuals with hip fracture remained in a nursing home for at least a year, and 50% were never able to walk again without assistance.5 A 6-year follow-up study of 185 patients who had experienced a hip fracture showed that only 9% were able to walk on their own.6 The health care expenditure attributable to osteoporotic fractures in the U.S. was estimated at $13.8 billion in 1995, 28% of which was spent on nursing home care.1

A study of osteoporotic fractures, a prospective cohort of 9516 postmenopausal women, identified several risk factors for the occurrence of hip fractures in community-living, white, postmenopausal women (Table I).7 More recently, Girman et al8 developed an algorithm based on the Minimum Data Set (MDS) to help identify nursing home residents at increased risk of osteoporotic fractures, including hip fractures (Table II). A cutoff of 4 on the algorithm had a sensitivity of 79.9% for predicting osteoporotic fractures in the development sample and 70.2% in the validation sample. This algorithm may help identify nursing home residents at increased risk of hip fractures who are likely to benefit from preventive measures. The occurrence of a hip fracture increases the risk of another hip fracture.

In a large population-based study in Rochester, MN, U.S. men with hip fractures had a 3.2-fold increase in the risk of a second hip fracture compared with those
without previous fractures. Similar findings were reported by other investigators. Living in a nursing home is a risk factor of recurrent hip fractures.

### Table I: Risk Factors for Hip Fractures in White Women

- Maternal history of hip fracture
- Decreased weight
- Poor health
- Previously treated hyperthyroidism
- Anticonvulsant or long-acting benzodiazepines
- Lack of exercise
- Pulse rate > 80 beats per minute at rest
- History of any fracture after age 50
- Consumption of caffeine
- Poor visual depth perception
- Inability to rise from a chair without using the arm
- Low bone mass

Efforts to prevent hip fractures in the nursing home should not only focus on augmenting bone mineral density (BMD) but also on instituting measures to prevent falls and on increasing the utilization of hip protectors (Figure). This article discusses such efforts and highlights antiresorptive therapies that are particularly useful in the nursing home setting.

### Increasing BMD

Low BMD is an important risk factor for hip fractures in the nursing home population, where osteoporosis is highly prevalent. One study reported an 85% prevalence of osteoporosis among new nursing home admissions. A large survey of nursing home residents found an osteoporosis prevalence of 63.5% for women age 65 to 74 years and 85.8% for women older than 85 years of age. A baseline assessment of BMD dual-energy x-ray absorptiometry (DXA) can: (1) establish the diagnosis of osteoporosis; (2) help determine the extensiveness of the evaluation for underlying disease; and (3) provide a baseline for monitoring. Assessment at the hip and spine by DXA is the standard procedure used to confirm suspected low BMD. Peripheral BMD measurements in nursing home patients are not reliable, as they may often result in many false negative and false positive results. The availability of DXA machines that are mobile (mounted in the back of a truck or bus) is limited. For practical reasons, the diagnosis of osteoporosis in nursing home residents is often made based on clinical grounds (prior fragility fractures).

### Table II: Algorithm for Predicting Fractures in the Nursing Home

<table>
<thead>
<tr>
<th>Factor</th>
<th>Level/Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>65-74: 1</td>
</tr>
<tr>
<td></td>
<td>75-84: 2</td>
</tr>
<tr>
<td></td>
<td>85-94: 3</td>
</tr>
<tr>
<td></td>
<td>&gt; 95: 0</td>
</tr>
<tr>
<td>Weight, pounds</td>
<td>&lt; 170: 1</td>
</tr>
<tr>
<td></td>
<td>≥ 170: 0</td>
</tr>
<tr>
<td>Height, inches</td>
<td>≤ 58: 0</td>
</tr>
<tr>
<td></td>
<td>58 &gt; height ≤ 63: 1</td>
</tr>
<tr>
<td></td>
<td>&gt; 63: 2</td>
</tr>
<tr>
<td>Locomotion on unit</td>
<td>Independent: 2</td>
</tr>
<tr>
<td></td>
<td>Supervision: 1</td>
</tr>
<tr>
<td></td>
<td>At least limited assistance needed: 0</td>
</tr>
<tr>
<td>Fell in last 180 days</td>
<td>No: 0</td>
</tr>
<tr>
<td></td>
<td>Yes: 1</td>
</tr>
<tr>
<td>Activities of daily living score</td>
<td>≤ 4: 1</td>
</tr>
<tr>
<td></td>
<td>&gt; 4: 0</td>
</tr>
<tr>
<td>Cognitive scale score</td>
<td>≤ 3: 1</td>
</tr>
<tr>
<td></td>
<td>&gt; 3: 0</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>Usually continent: 1</td>
</tr>
<tr>
<td></td>
<td>or usually incontinent: 0</td>
</tr>
<tr>
<td></td>
<td>Occasionally incontinent: 0</td>
</tr>
</tbody>
</table>

Score
and bone density assessment is rarely required.

Table III lists the medications currently approved by the U.S. Food and Drug Administration (FDA) for the prevention and/or treatment of osteoporosis. Among these, alendronate, risedronate, parathyroid hormone (PTH), and estrogen have been shown to decrease both vertebral and hip fractures. Calcium carbonate has been shown to decrease the risk of vertebral fractures but not hip fractures. Calcium and vitamin D supplementation have been shown to decrease the risk of both vertebral and nonvertebral fractures. They are regarded as dietary supplements and are thus not regulated by the FDA.

**Calcium**

A National Institutes of Health (NIH) Consensus Development Conference panel in 1994 considered an elemental calcium intake of 1500 mg/day to be optimal for postmenopausal women not taking estrogen and 1000 mg/day optimal for women on hormone replacement therapy. Both of these figures are greater than the current recommended dietary allowance (RDA) for adult women, which is 800 mg/day. The panel also suggested a daily elemental calcium intake of 1000 mg/day for men under age 65 years and 1500 mg/day for men over age 65 years. The median daily dietary calcium intake for women in the United States is 574 mg and 826 mg for men. The average American diet contains 389 mg of calcium per 1,000 kcal. Consequently, the majority of older adults (especially those who are institutionalized) need calcium supplementation. Calcium carbonate is the most frequent formulation prescribed. Calcium carbonate, however, requires an acidic environment for optimal absorption, and in patients taking H₂ blockers or proton pump inhibitors, calcium citrate may be preferable. When supplementing calcium, mucosal absorption may be a rate-limiting step, and doses over 600 mg per day should be given in divided doses.

Calcium supplementation has been shown to increase BMD and prevent vertebral fractures. The effect of calcium supplementation alone on hip fractures was not tested. However, calcium and vitamin D co-supplementation has been shown to decrease the incidence of hip fractures and other nonvertebral fractures in institutional-
Vitamin D

The RDA for vitamin D is 400 IU/day up to age 70 years, and 600 IU/day thereafter for both men and women. The active hormone, 1,25(OH)\(_2\)D\(_3\), is produced by sequential hydroxylation of vitamin D\(_3\) in the liver by the enzyme 25-hydroxylase and in the kidney by the enzyme 1α-hydroxylase.\(^{15}\) The active hormone acts on the intestine to enhance absorption of calcium and phosphorous. Up to 90% of vitamin D\(_3\) is derived from activation of 2,dehydrocholesterol in sun-exposed skin. A minimum of 30-60 minutes of sun exposure per week is necessary to maintain adequate levels.

There appears to be an age-related decline in renal 1,25(OH)\(_2\)D\(_3\) production, attributable in part to diminished renal response to PTH,\(^{23}\) as well as a decrease in the renal 1α-hydroxylase enzyme activity, which is needed for the production of 1,25(OH)\(_2\)D.\(^{24}\) Furthermore, aging is associated with decreased cutaneous synthesis of vitamin D\(_3\) after sunlight exposure, as well as decreased hepatic conversion of vitamin D\(_3\) to 25(OH)D\(_3\). Evidence also exists that, with age, intestinal mucosal cells become relatively resistant to the effect of 1,25(OH)\(_2\)D\(_3\), thus impairing intestinal absorption of calcium. All of this is compounded by the fact that the great majority of institutionalized elderly are in low vitamin D status secondary to inadequate diet and decreased exposure to sunlight.\(^{25}\) A recent Cochrane review indicated that the administration of vitamin D\(_3\) alone without calcium co-supplementation was not associated with any reduction in incidence of hip fractures or other nonvertebral fractures.\(^{26}\)

Chapuy et al\(^{21}\) showed that calcium and vitamin D supplementation decreased hip fractures among elderly nursing home residents. In this study, the authors randomized 3270 female residents (mean age 84 ± 6 years) from 180 French nursing homes to receive either 1200 mg of elemental calcium and 800 IU of cholecalciferol (vitamin D\(_3\); \(n = 1634\)) or placebo (\(n = 1636\)) daily and followed them for 18 months. At the end of the follow-up period, the number of nonvertebral fractures was 43% lower in the intervention group compared with the control group; the mean serum PTH level decreased by 44%, and serum 25(OH)D\(_3\) levels increased by 162% over the baseline value. The mean baseline 25(OH)D serum level of study participants in this trial was low-normal, indicating that a high percentage probably had frank vitamin D deficiency. In spite of these clear benefits of calcium and vitamin D supplementation among institutionalized elderly, such supplements are markedly underutilized in the nursing home setting.\(^{27}\)

Alendronate

The Fracture Intervention Trial (FIT) provided strong evidence that the oral bisphosphonate, alendronate, prevents hip fractures in postmenopausal women with osteoporosis.\(^{28,29}\) In this trial, women age 55-81 years with low femoral neck BMD were enrolled in two groups based on the presence or absence of one or more vertebral fractures at baseline. The first report of the trial included 2027 women with at least one vertebral fracture at baseline who were randomly assigned to placebo (\(n = 1005\)) or alendronate (\(n = 1022\); 5 mg/day for the first 24 months and 10 mg/day for the remaining 12 months). The relative hazard ratio for hip fracture for alendronate versus placebo was 0.49.\(^{28}\)

The second report studied the effect of alendronate on fractures in women who had low BMD but no vertebral fractures. In this study, 4272 women with low femoral BMD were randomized to alendronate (5 mg/day for 2 years followed by 10 mg/day) or placebo. Subjects were followed for an average of 4.2 years. Alendronate decreased the risk of nonspinal fractures by 36% in women with baseline osteoporosis at the
femoral neck (BMD > 2.5 standard deviations below the normal of young women mean) but not in those with higher BMD values. More recently, Schnitzer et al showed that alendronate 70 mg once a week for a year provided similar efficacy to daily administration of alendronate 10 mg on BMD (lumbar spine, hip, and total body). The study, however, did not have statistical power to examine the impact of hip fracture incidence. Alendronate administered at 10 mg orally once a day or 70 mg orally once a week has been approved by the FDA for the treatment of osteoporosis.

The most frequent toxicity of alendronate is on the esophagus and stomach, where it may cause direct irritation and ulceration. To avoid this complication, it is recommended that the patient remain upright for at least a half hour after taking the pill. This requirement may prove difficult to implement in the nursing home due to limited staffing. A recent report tested the efficacy and tolerability of alendronate 10 mg/day orally for the treatment of osteoporosis among 327 elderly female nursing home residents with osteoporosis from 25 long-term care facilities. In this 2-year, multicenter, randomized, double-blind, placebo-controlled study, alendronate significantly improved both hip and spine BMD and was well tolerated. The study was not powered to test effect on fracture risk.

Risedronate

Risedronate is another oral bisphosphonate approved by the FDA for the prevention and treatment of osteoporosis. In the Vertebral Efficacy with Risedronate Therapy (VERT) trial, 2458 postmenopausal women, who were younger than 85 years of age and had one or more vertebral fractures, were randomly assigned to receive risedronate (2.5 or 5 mg/day) or placebo for 3 years. The 2.5 mg/day dosage of risedronate was discontinued after 1 year. Treatment with 5 mg/day of risedronate decreased the cumulative incidence of new vertebral fractures by 41% over 3 years compared with placebo. The cumulative incidence of new nonvertebral fractures was reduced by 39%.

The more recently published Hip Intervention Program (HIP) trial studied 5445 women age 70-79 years with osteoporosis and 3886 women older than 80 years with nonskeletal risk factors for hip fracture or low BMD at the femoral neck. Subjects were randomized into a treatment group who received risedronate 5 mg/day orally, or a placebo group. The treatment group showed significantly higher BMD as early as six months after starting therapy compared with the control group. The incidence of hip fractures in the study group decreased by 41%. However, in the older group, who were recruited on the basis of risk factors for hip fractures, there was no significant reduction of fracture rate, even in those with documented BMD evidence of osteoporosis. This observation emphasizes the importance of other strategies aimed at preventing injurious falls (eg, hip protectors) in addition to starting pharmacologic therapy in the very old for risk of hip fractures. Risedronate 5 mg/day orally is approved by the FDA for the prevention and treatment of osteoporosis. More recently, risedronate 35 mg/week orally was approved by the FDA for the treatment of osteoporosis. Similar to alendronate, it is recommended that the patient remain upright for 30 minutes after taking risedronate.

Parathyroid Hormone

Parathyroid hormone was recently approved by the FDA for the treatment of osteoporosis. This approval was based on the study by Neer et al, who randomly assigned 1637 postmenopausal women with prior vertebral fractures to receive subcutaneously 20 or 40 mg of PTH (1-34) or placebo daily for a median duration of 21 months. The treatment significantly increased BMD at the lumbar spine and femoral neck and de-
creased the incidence of both vertebral and nonvertebral fractures. PTH administration may be indicated in nursing home residents with very low BMD (< 3 standard deviants below the mean for young adults). The duration of PTH therapy should be limited to 2 years. The safety of long-term administration of PTH is not yet determined. The course of PTH therapy should be followed by the administration of a bisphosphonate in order to preserve any BMD gains. Patients receiving PTH should be carefully monitored for the development of hypercalcemia. There are currently several trials underway to evaluate the effect of adding a bisphosphonate to PTH on BMD and fracture risk.

Estrogen

The Postmenopausal Estrogen/Progestin Interventions (PEPI) trial clearly demonstrated the beneficial effects of estrogen replacement therapy on BMD in postmenopausal women. Until recently, the effect of estrogen on hip fractures was mainly based on the findings from the Study of Osteoporotic Fractures (SOF), an epidemiologic study that involved a cohort of 9704 postmenopausal women age 65 years or older. Data from this study showed that current estrogen use was associated with a significant reduction in the relative risk for wrist fractures as well as all nonspinal fractures, and that the initiation of estrogen soon after menopause was associated with the lowest fracture risk. More recently, results from the Women’s Health Initiative randomized controlled trial showed a significant protective effect of estrogen against hip fracture (estimated hazard ratio of .66). In this report, however, the overall risks from estrogen use exceeded the overall benefits. The side effects attributed to estrogen use in this trial (notably the increased risk of coronary heart disease, stroke, and breast cancer) were likely influenced by the formulation of estrogen utilized in this study (conjugated equine estrogen), which is unnatural to the human body. Estradiol, the primary estrogen produced by the human ovaries, is available in the form of skin patches, tablets, and creams and is currently the preferred form of estrogen replacement therapy. The risks and benefits of estradiol use in postmenopausal women is currently under investigation in the Women’s International Study of Long Duration Oestrogen after Menopause (WISDOM) trial in Europe.

FALL PREVENTION

All nursing home residents with osteoporosis should be assessed for the presence of fall risk factors (Table IV). More than one factor is often identified in institutionalized elderly. Subsequently, interventions targeting identified risk factors should be implemented. Such interventions include exercise programs designed to improve strength or balance, education programs on home safety and fall prevention, medication adjustments, and environmental modifications. A recent Cochrane review showed that, although isolated interventions (eg, exercise programs) were not effective in preventing falls, significant reduction in the risk of falling occurred from interventions that targeted multiple identified risk factors in individual patients (odds ratio .77; 95% CI, .64 to .91) as well as from interventions that focused on be-

<table>
<thead>
<tr>
<th>Table IV: Risk Factors for Falls</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Muscle weakness</td>
</tr>
<tr>
<td>• Balance/gait deficit</td>
</tr>
<tr>
<td>• Impaired vision</td>
</tr>
<tr>
<td>• Impaired mobility</td>
</tr>
<tr>
<td>• Cognitive deficiency</td>
</tr>
<tr>
<td>• Inability to perform activities of daily living</td>
</tr>
<tr>
<td>• Orthostatic hypotension</td>
</tr>
<tr>
<td>• Environmental hazards (eg, unstable furniture, poor lighting, and hazardous rugs and carpets)</td>
</tr>
</tbody>
</table>

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havioral modifications that targeted environmental hazards plus other risk factors (odds ratio, .81; 95% CI, .71 to .93).40

In a recent study, the implementation of a multidisciplinary program that included staff education, environment modification, exercise programs, supplying and reporting aids, reviewing drug regimens, providing free hip protectors, having post-fall problem-solving conferences, and guiding staff significantly decreased the risk of falls and hip fractures among institutionalized elderly.41

**HIP PROTECTORS**

In 1993, Lauitzen et al.12 randomized 665 elderly subjects from 10 Danish nursing homes to an intervention group that wore hip protectors or to a control group that did not. After 11 months of follow-up, the incidence of hip fractures was 53% lower in the intervention group. In addition, none of the subjects assigned to wear a hip protector who had had a hip fracture were wearing hip protectors at the time of the fracture. Subsequently, several other studies from other countries confirmed the findings of the Danish study.43-45 Poor compliance was a frequent finding cited in all these studies. Nursing home patients with osteoporosis who are at risk of falling should be prescribed hip protectors.

**CONCLUSION**

Hip fracture prevention in the nursing home should involve measures to increase bone density, prevent falls, and protect the hip. The introduction of once weekly dosing of alendronate and risedronate is expected to increase the utilization of such therapies in the nursing home. The recent approval of PTH therapy adds a new powerful medication that may help nursing home patients with severe osteoporosis.

**References**


ERRATUM

In the article “Managing Alternative Therapies in the Nursing Home” that appeared in the December 2002 issue, the statement “Tamoxifen is derived from the Pacific yew tree” is incorrect. Tamoxifen is a triphenylethylene derivative widely used as a nonsteroidal antiestrogen. Tamoxifen is synthetic. Paclitaxel is an antieoplastic agent, which is derived from the Pacific Yew. Paclitaxel’s use in the U.S. has been largely replaced in recent years by related compounds to the point where it is no longer listed in the 2003 PDR. The Journal thanks Dr. Martin C. DeGraw for the correction.
We regret the error.