ORIGINAL ARTICLE

Significantly Fewer Refractures After Vertebroplasty in Patients Who Engage in Back-Extensor–Strengthening Exercises

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OBJECTIVE: **To determine whether patients with osteoporotic compression fractures would have decreased fracture recurrence or a longer time before refracture after percutaneous vertebroplasty (PVP) if they also participated in the Rehabilitation of Osteoporosis Program–Exercise (ROPE) instruction, which includes back-strengthening exercises.**

PATIENTS AND METHODS: **We reviewed and collected data from the medical records of 507 patients with osteoporosis who were treated at Mayo Clinic's site in Rochester, MN, from July 1, 1998, through August 31, 2005. Patients older than 55 years with at least 1 radiographically confirmed nontraumatic vertebral compression fracture (VCF) were identified, and those with evidence of secondary osteoporosis, traumatically induced VCF, long-term oral corticosteroid use, or bone malignancy were excluded. The remaining 57 patients were categorized into 3 groups: those receiving treatment with ROPE only (n=20), PVP only (n=20), or both PVP and ROPE (n=17). The end point was the refracture date or date of the last recorded follow-up if no refracture occurred. Statistical analysis of time-to-recurrence data was performed using the Kaplan-Meier method and the log-rank test (*P*<.05).**

RESULTS: **The median time before refracture for patients treated with PVP was 4.5 months (95% confidence interval [CI]), 1.4-9.3 months; for patients treated with ROPE only, 60.4 months (95% CI, 27.6 months-upper limit undefined); and for patients treated with PVP-ROPE, 20.4 months (95% CI, 2.8 months-upper limit undefined) (*P*<.001).**

CONCLUSION: **This retrospective study showed that a targeted exercise program after PVP significantly decreased fracture recurrence. Refracture rates also were lower in the ROPE-only group vs the PVP-only group.**

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BMD = bone mineral density; CI = confidence interval; PVP = percutaneous vertebroplasty; ROPE = Rehabilitation of Osteoporosis Program–Exercise; VCF = vertebral compression fracture

Osteoporosis is associated with decreased bone strength that markedly increases the risk of vertebral compression fractures (VCFs).[1] Fractures can remain asymptomatic, or they can be detected when a patient's posture is kyphotic or when a patient is evaluated radiographically for unrelated conditions.[2] Only one-third of patients with osteoporotic VCFs seek medical attention for back pain symptoms.[2,3] However, of those symptomatic VCF patients, a considerable number have severe and intractable pain that is unresponsive to activity modification, bracing, or pain medication.

Percutaneous vertebroplasty (PVP) is a minimally invasive procedure that has been used to treat intractable pain associated with both acute[4-6] and chronic[7] osteoporotic VCFs. The range of pain reduction in response to this intervention is reported to be 17% to 93%.[4,7,8] However, post-PVP symptomatic refractures are common.[9-12] Few published studies examining the rate of refracture have compared patients undergoing PVP with those treated with rehabilitative measures. A study by Diamond et al[4] compared PVP with conservative care but did not evaluate back-strengthening exercises (conservative measures consisted mainly of analgesic therapy).

Little is known about the effects of exercise on refracture rates for patients with osteoporosis who are treated with PVP. Percutaneous vertebroplasty can result in immediate pain relief,[4,6] but it also is associated with refracture at adjacent vertebrae within the first year after the procedure.[9,10,13] Previous studies have shown that exercise reduces the risk of vertebral and nonvertebral fractures.[14-16] In several studies, Sinaki et al[15,17-20] showed that healthy, postmenopausal women who engaged in back-extensor–strengthening exercises had less risk of falling and a lower incidence of VCF and lower back pain. None of these studies specifically addressed women with osteoporosis who had undergone PVP.

The Rehabilitation of Osteoporosis Program–Exercise (ROPE) instruction incorporates isometric back-extensor muscle strengthening and proprioceptive postural retraining.[17-19,21-23] We hypothesized that targeted back-extensor exercises, such as those found in the ROPE program, could benefit patients with osteoporosis and PVP-treated VCFs by decreasing the refracture rates or increasing the time before refracture.

PATIENTS AND METHODS

Before initiation of this study, the approval of the Mayo Clinic Institutional Review Board was obtained. A diagnosis-specific list of patients was used to identify patients with osteoporosis who were treated at Mayo Clinic's site in Rochester, MN, from July 1, 1998, through August 31, 2005, and

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the medical records of 507 of these patients were sequentially analyzed. Patients were included in our study if they were older than 55 years, had a confirmed diagnosis of osteoporosis, and had at least 1 nontraumatic VCF. Patients were excluded (n=450) if we found evidence of secondary osteoporosis, traumatically induced VCF, long-term oral corticosteroid use, or bone malignancy. After the desired number of patients in the PVP (n=20) and ROPE (n=20) groups was obtained, we focused on obtaining data from patients who had undergone both interventions. This proved to be difficult, with an exhaustive search of hundreds of records yielding few results. To save time, we discontinued the search for medical records after we obtained data from 17 patients.

Medical records were analyzed to confirm the diagnosis of osteoporosis, radiographic proof of VCF, and the presence or absence of PVP. We recorded the date of the first medical visit for symptomatic back pain attributable to VCF or the first radiograph documenting VCF, date of the PVP procedure, date of the first session of ROPE, and date of refracture. For patients who did not have a refracture, the date of the last recorded follow-up visit was used.

Additional patient data were collected, including sex, age, height, weight, bone mineral density (BMD) total T score, femoral neck T score, lumbar spine T score, and use of antiresorptive medication. Refracture was determined by symptoms and confirmed by radiography.

Statistical Analyses

Statistical analyses were performed with proportional hazards regression. In addition to anthropometric and BMD data, we analyzed the recorded interval between PVP and date of refracture and between ROPE initiation and date of refracture. Comparisons between groups were performed with analysis of variance. If patient records showed no evidence of symptoms during the designated study period, the last follow-up appointment date for osteoporosis or the date of the most recent spine radiograph was used as the end date for interval calculations. The Fisher exact test was used to analyze the antiresorptive medication data. Kaplan-Meier and log-rank analysis were used to compare the median time-to-refracture intervals in the PVP, ROPE, and PVP-ROPE groups. Statistical significance was defined at $P<.05$. Data were analyzed using JMP 6 statistical software (SAS Institute, Cary, NC).

RESULTS

No significant differences in age ($P=.72$), sex ($P=.27$), height ($P=.50$), weight ($P=.26$), and BMD total T score ($P=.68$) were observed among groups. These variables did not affect time before refracture: age ($P=.39$), sex ($P=.33$), height ($P=.87$), weight ($P=.10$), and BMD total T score ($P=.71$). The BMD values for the lumbar spine and femoral neck are provided in the Table.

TABLE. **Data on BMD for Femoral Neck, Lumbar Spine, and Total T Scores of the 3 Groups**[a]

Group	Femoral neck BMD	Lumbar spine BMD	T score
PVP	–2.8 (–1.5 to –4.3)	–2.8 (–0.3 to –3.8)	–2.8 (–0.4 to –4.5)
ROPE	–2.5 (–1.6 to –4.3)	–2.7 (–0.26 to –4.8)	–2.7 (–1.2 to –4.4)
PVP-ROPE	–2.6 (–1.6 to –4.20)	–2.6 (–1.6 to –5.3)	–2.3 (–1.0 to –3.9)

[a] Values given as median (interquartile range). BMD = bone mineral density; PVP = percutaneous vertebroplasty; ROPE = Rehabilitation of Osteoporosis Program–Exercise.

We noted that 13 patients (65%) from the ROPE group, 12 (60%) from the PVP group, and 14 (82%) from the PVP-ROPE group were being treated with various antiresorptive medications. The Fisher exact test showed no association between use of antiresorptive medication and the presence or absence of refracture in any of the 3 patient groups ($P=.97$).

As shown in the Figure, patients in the PVP group had a median time before refracture of 4.5 months (95% confidence interval [CI], 1.4-9.3 months); patients in the ROPE group, 60.4 months (95% CI, 27.6 months-upper limit undefined); and patients in the PVP-ROPE group, 20.4 months (95% CI, 2.8 months-upper limit undefined). Log-rank analysis revealed a small but statistically significant difference in time before refracture between the 2 groups that participated in ROPE (ROPE and PVP-ROPE) ($P=.04$) and between these groups and the PVP group ($P<.001$).

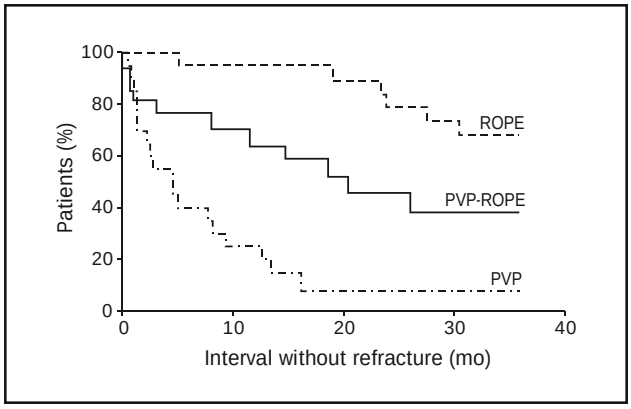

FIGURE. Survival plot showing the percentage of patients in each group with no refracture at various time points ($P<.001$). PVP = percutaneous vertebroplasty; ROPE = Rehabilitation of Osteoporosis Program–Exercise.

Analysis of the refracture data showed that 75% of patients in the PVP group had a refracture within 12 months. Within 12 months, 5% of patients in the ROPE group and 35% of patients in the PVP-ROPE group had a refracture.

DISCUSSION

Many of the estimated 44 million people in the United States with osteoporosis or osteopenia[24] will eventually develop spontaneous, nontraumatic VCFs. In most patients, VCFs will respond to conservative treatment. However, for those patients with intractable pain, PVP could be an effective treatment.[21,22,25] Percutaneous vertebroplasty is a minimally invasive procedure involving the percutaneous placement of bone cement into the collapsed or partially collapsed vertebrae. Although this procedure offers immediate pain relief for many patients,[4,6,23] it is also associated with a substantial refracture rate. Most reported refractures occur within 12 months after the procedure and affect adjacent vertebrae.[9,11] In a recent study of 432 post-PVP patients at Mayo Clinic, Trout et al[26] reported a 19.9% refracture rate. However, the incidence of recurrent VCF after PVP varies widely in the literature; most of these data are derived from retrospective studies.

Recent prospective studies have reported an average refracture rate after PVP of approximately 20%.[10,13] This rate may be similar to that seen in the general osteoporotic population, for whom a prior fracture is a strong predictor of subsequent fracture,[3] usually within the first year.[10] Posture mechanics, mobility status, or level of deconditioning can be related indirectly to the risk of fracture, whereas increased activity levels in the post-PVP population, lifestyle, and genetics can also influence the rate of fracture recurrence. Our retrospective data showed a post-PVP refracture rate higher than many that were reported in the literature, but the median time before refracture for the PVP-ROPE group (20.4 months [95% CI, 2.8 months-upper limit undefined]) was also longer than in prior reports.[9,11] For patients with osteoporosis and VCF, exercise decreases the use of analgesics and improves quality of life,[27] prevents vertebral bone loss,[19] and possibly prevents development of osteoporotic fractures.[15] Feskanich et al[14] reported decreased risk of hip fractures among postmenopausal women who walked approximately 1 hour per week at an average pace. In a prospective study by Sinaki et al,[15] a reduced incidence of VCFs was observed among healthy, postmenopausal women who participated in a back-extensor–strengthening program several years before the onset of osteoporosis.

At our institution, the ROPE program was developed specifically for patients with osteoporosis who are treated in the Department of Physical Medicine and Rehabilitation. In animal models, similar approaches have shown improved bone characteristics, such as fatigue resistance, strength, bone mineral content, and trabecular number.[27-29]

In this study, the groups that received ROPE instruction had longer fracture-free intervals and fewer fractures than the group that did not participate in ROPE. Although several patients in each study group were receiving antiresorptive therapy, no difference in refracture rate was observed in these patients. A number of factors could account for this lack of difference in refracture rate: (1) in many instances, patients were prescribed antiresorptive medications after the diagnosis of osteoporosis or VCF was made; (2) patients had a relatively short duration of drug treatment; or (3) patients could have had adherence issues that were not noted in the medical record. Because of these limitations, no conclusion could be drawn about the effect of antiresorptive medication use and refracture data in this study population.

Analysis of variance of the BMD data from our study showed no significant difference among the 3 groups (P=.68), suggesting that the improved refracture rates and the longer time before refracture of the groups receiving ROPE instruction (ROPE only and PVP-ROPE) were not directly attributable to BMD.

Our study has several limitations. First, retrospective studies can inherently introduce investigator bias or other biases that would be mitigated in randomized controlled trials. Second, although we screened 507 patient records, only a small number were included in this study, making interpretation of the statistical analysis somewhat difficult. We selected a broad criterion (diagnosis of osteoporosis) for the original search because we thought that it would ensure the capture of the maximum number of patients meeting both inclusion and exclusion criteria. Third, one of the patients in the PVP-ROPE group had undergone PVP at a different Mayo Clinic site. Because we had a limited number of patients in the combined PVP-ROPE group, we elected to retain her data but recognize that the inclusion could potentially bias the results. Additionally, our study included only patients who returned for follow-up, whereas others likely were lost to follow-up or sought follow-up care at other institutions. Fourth, magnetic resonance imaging is the best tool for accurately identifying refractures in the osteoporotic population; however, because this was a retrospective study, we were limited to existing follow-up data, mainly radiographs and documentation by clinicians. Last, adherence could influence the outcome of any intervention, but it was not tracked successfully in this study. Analysis of adherence in future studies could provide valuable in-sight into how well the ROPE program reduces fractures.

CONCLUSION

Our data suggest that the addition of ROPE could extend the time before refracture in this population of post-PVP patients. Because ROPE has few risks, addition of ROPE to post-PVP protocols is prudent for medically appropriate patients. Until better, prospectively derived data are available, we recommend inclusion of ROPE instruction after PVP. As randomized studies of rehabilitation for patients with osteoporosis are performed to determine the efficacy of exercise, the same principles need to be applied to PVP studies if the outcomes of the 2 interventions are to be productively and accurately compared.

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REFERENCES

1. Seeman E, Delmas PD. Bone quality: the material and structural basis of bone strength and fragility. *N Engl J Med.* 2006;354(21):2250-2261.

2. Vogt TM, Ross PD, Palermo L, et al, Fracture Intervention Trial Research Group. Vertebral fracture prevalence among women screened for the Fracture Intervention Trial and a simple clinical tool to screen for undiagnosed vertebral fractures. *Mayo Clin Proc.* 2000;75(9):888-896.

3. Delmas PD, Genant HK, Crans GG, et al. Severity of prevalent vertebral fractures and the risk of subsequent vertebral and nonvertebral fractures: results from the MORE trial. *Bone.* 2003;33(4):522-532.

4. Diamond TH, Champion B, Clark WA. Management of acute osteoporotic vertebral fractures: a nonrandomized trial comparing percutaneous vertebroplasty with conservative therapy. *Am J Med.* 2003;114(4):257-265.

5. Mehbod A, Aunoble S, Le Huec JC. Vertebroplasty for osteoporotic spine fracture: prevention and treatment. *Eur Spine J.* 2003 Oct;12(suppl 2):S155-S162. Epub 2003 Sep 19.

6. Barr JD, Barr MS, Lemley TJ, McCann RM. Percutaneous vertebroplasty for pain relief and spinal stabilization. *Spine.* 2000;25(8):923-928.

7. Brown DB, Gilula LA, Sehgal M, Shimony JS. Treatment of chronic symptomatic vertebral compression fractures with percutaneous vertebroplasty. *AJR Am J Roentgenol.* 2004;182(2):319-322.

8. Lin JT, Lane JM. Nonmedical management of osteoporosis. *Curr Opin Rheumatol.* 2002;14(4):441-446.

9. Syed MI, Patel NA, Jan S, Harron MS, Morar K, Shaikh A. New symptomatic vertebral compression fractures within a year following vertebroplasty in osteoporotic women. *AJNR Am J Neuroradiol.* 2005;26(6):1601-1604.

10. Lindsay R, Silverman SL, Cooper C, et al. Risk of new vertebral fracture in the year following a fracture. *JAMA.* 2001;285(3):320-323.

11. Tanigawa N, Komemushi A, Kariya S, Kojima H, Shomura Y, Sawada S. Radiological follow-up of new compression fractures following percutaneous vertebroplasty. *Cardiovasc Intervent Radiol.* 2006;29(1):92-96.

12. Sinaki M, Huntoon E, Yang R. Subsequent fracture after vertebroplasty [abstract P148]. *Calcif Tissue Int.* 2004;74(suppl 1):S82.

13. Voormolen MH, Lohle PN, Juttmann JR, van der Graaf Y, Fransen H, Lampmann LE. The risk of new osteoporotic vertebral compression fractures in the year after percutaneous vertebroplasty. *J Vasc Interv Radiol.* 2006;17(1):71-76.

14. Feskanich D, Willett W, Colditz G. Walking and leisure-time activity and risk of hip fracture in postmenopausal women. *JAMA.* 2002;288(18):2300-2306.

15. Sinaki M, Itoi E, Wahner HW, et al. Stronger back muscles reduce the incidence of vertebral fractures: a prospective 10 year follow-up of postmenopausal women. *Bone.* 2002;30(6):836-841.

16. Gregg EW, Cauley JA, Seeley DG, Ensrud KE, Bauer DC, Study of Osteoporotic Fractures Research Group. Physical activity and osteoporotic fracture risk in older women. *Ann Intern Med.* 1998;129(2):81-88.

17. Sinaki M, Mikkelsen BA. Postmenopausal spinal osteoporosis: flexion versus extension exercises. *Arch Phys Med Rehabil.* 1984;65(10):593-596.

18. Sinaki M, Lynn SG. Reducing the risk of falls through proprioceptive dynamic posture training in osteoporotic women with kyphotic posturing: a randomized pilot study. *Am J Phys Med Rehabil.* 2002;81(4):241-246.

19. Sinaki M, Wahner HW, Offord KP, Hodgson SF. Efficacy of nonloading exercises in prevention of vertebral bone loss in postmenopausal women: a controlled trial. *Mayo Clin Proc.* 1989;64(7):762-769.

20. Fast facts on osteoporosis. Washington, DC: National Osteoporosis Foundation; 2006. www.nof/org/osteoporosis/diseasefacts.htm. Accessed February 22, 2006.

21. Malmros B, Mortensen L, Jensen MB, Charles P. Positive effects of physiotherapy on chronic pain and performance in osteoporosis. *Osteoporos Int.* 1998;8(3):215-221.

22. Sinaki M. Rehabilitation of osteoporotic fractures in the spine. In: *Physical Medicine and Rehabilitation: State of the Art Reviews.* Vol 9. Philadelphia, PA: Hanley & Belfus; 1995:105-123.

23. Kaplan RS, Sinaki M, Hameister MD. Effect of back supports on back strength in patients with osteoporosis: a pilot study. *Mayo Clin Proc.* 1996;71(3):235-241.

24. Mathis JM, Barr JD, Belkoff SM, Barr MS, Jensen ME, Deramond H. Percutaneous vertebroplasty: a developing standard of care for vertebral compression fractures. *AJNR Am J Neuroradiol.* 2001;22(2):373-381.

25. Jensen ME, Evans AJ, Mathis JM, Kallmes DF, Cloft HJ, Dion JE. Percutaneous polymethylmethacrylate vertebroplasty in the treatment of osteoporotic vertebral body compression fractures: technical aspects. *AJNR Am J Neuroradiol.* 1997;18(10):1897-1904.

26. Trout AT, Kallmes DF, Kaufmann TJ. New fractures after vertebroplasty: adjacent fractures occur significantly sooner. *AJNR Am J Neuroradiol.* 2006;27(1):217-223.

27. Robling AG, Hinant FM, Burr DB, Turner CH. Improved bone structure and strength after long-term mechanical loading is greatest if loading is separated into short bouts. *J Bone Miner Res.* 2002;17(8):1545-1554.

28. Rubin C, Turner AS, Muller R, et al. Quantity and quality of trabecular bone in the femur are enhanced by a strongly anabolic, noninvasive mechanical intervention. *J Bone Miner Res.* 2002;17(2):349-357.

29. Warden SJ, Hurst JA, Sanders MS, Turner CH, Burr DB, Li J. Bone adaptation to a mechanical loading program significantly increases skeletal fatigue resistance. *J Bone Miner Res.* 2005 May;20(5):809-816. Epub 2004 Dec 20.