Efficacy of Percutaneous Vertebral Augmentation and Use of Physical Therapy Intervention following Vertebral Compression Fractures in Older Adults: A Systematic Review

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ABSTRACT

Purpose: The purpose of this systematic literature review was to summarize information on the efficacy of percutaneous vertebral augmentation (PVA) and the incorporation of physical therapy intervention following PVA for vertebral compression fractures (VCF). **Methods:** Literature searches were completed using the Cochrane Library: Cochrane Database of Systematic Reviews (Cochrane Reviews); Agency for Healthcare Research and Quality (AHRQ): National Guideline Clearinghouse; Physiotherapy Evidence Database (PEDro); Medline; and Cumulative Index of Nursing and Allied Health Literature (CINAHL) through August 2005. **Results:** Seventeen relevant studies were identified. They reported favorable outcomes (eg, earlier mobility, decreased pain, and improved spinal posture) after PVA. No study addressed physical therapy intervention after PVA. **Conclusion:** PVA appears to be an effective treatment option for individuals with VCF. However, research dealing with physical therapy after PVA is needed.

Key Words: vertebroplasty, kyphoplasty, physical therapy, rehabilitation, outcomes

INTRODUCTION

Osteoporosis and Vertebral Compression Fractures

Osteoporosis affects 200 million individuals worldwide[1] and is an especially common problem among elderly females, resulting in thoracic and lumbar vertebral compression fractures (VCF). It is estimated that 25% of women over age 50 will experience one or more VCF[2,3] and there are 700,000 VCF annually[4] with an enormous economic impact.[5] According to the World Health Organization, osteoporosis is diagnosed when an individual's bone density t-score is 2.5 standard deviations below the mean as measured by a dual emission x-ray absorptiometry (DEXA) scan.[6] Osteopenia, the precursor to osteoporosis, is characterized by a t-score of 1 to 2.5 standard deviations below the mean.[6]

The complications of osteoporosis and VCF include pain, postural deformities with related pulmonary compromise, impaired balance, decreased mobility and function, and more frequent and longer hospital stays.[7-9] Additionally, these fractures may trigger a decline in health resulting in permanent disability or death of the older adult.[9-11]

Compression fractures may result from a fall or minor trauma.[12] Sometimes VCF occur spontaneously with simple activities like coughing; turning or twisting; attempting to rise from a chair; stepping on or off a step; or picking up an object, pet, or grandchild.[3,12] Vertebral compression fractures involving the anterior portion of the vertebral body are called anterior wedge fractures. These fractures are usually stable and do not result in neurological compromise. Burst fractures involve the entire vertebral body and may be unstable.[13] Both types of VCF alter spinal postural alignment and support of the vertebral column.[14] Changes in postural alignment may lead to pain, respiratory compromise, and impaired functional mobility.[8,9,14] A single VCF may result in a 9% loss of forced vital capacity.[15] Pain frequently increases with weight bearing, is most severe during the first few weeks, and decreases with rest and inactivity.[12] Individual pain tolerance is variable, resulting in different levels of functional limitation.[3]

Conservative Intervention for VCF

Conservative, nonoperative intervention following VCF focuses on pain relief, strengthening, limiting motion of the spine, and maintaining functional activities within the individual's ability and tolerance.[16,17] Bed rest, immobility, analgesics, and bracing are common nonsurgical interventions for VCF.[18,19] Bracing provides support, decreases pain, and allows improved functional mobility.[20,21]

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Surgical Intervention

When conservative intervention does not provide desired results within a few weeks or months, VCF can be treated surgically.[4] Surgical intervention, known as percutaneous vertebral augmentation (PVA), following VCF includes surgical techniques called vertebroplasty and kyphoplasty.[16,22] Other PVA terminology includes percutaneous vertebroplasty and balloon kyphoplasty.[23] These procedures are being used with increased frequency in the United States.

Vertebroplasty was developed in France in 1984.[24] Although vertebroplasty was initially used to treat patients with cancer, it has gained popularity for other conditions and patient populations.[23,24] Vertebroplasty is performed while a patient is prone and under local or general anesthesia. It involves fluoroscopic imaging to guide the injection of polymethylmethacrylate cement into the fractured vertebral body to hold and support the fractured bone.[23,24]

Kyphoplasty was first used in the United States in 1988.[22] During kyphoplasty, the surgeon creates a space by expanding a 'balloon' in the vertebral body and then fills the space with bone cement.[22,25] After the cement is inserted, the patient is placed in supine for approximately 1 hour while the cement hardens.[24] Further procedural details related to PVA are described by Deen et al,[11] Mathis et al,[23] and Deramond et al.[24]

Both vertebroplasty and kyphoplasty provide pain relief and support the vertebral column. In addition, kyphoplasty restores vertebral height[21,25-27] and has a decreased chance of cement leakage compared to vertebroplasty.[22] However, Mathis et al report that kyphoplasty minimally improves vertebral height, involves greater risk due to the use of general anesthesia, and costs 10 to 20 times more than vertebroplasty.[26] Neither vertebroplasty nor kyphoplasty has been compared to conservative treatment in a randomized trial.[26]

Purpose

The purpose of this systematic literature review was to provide the reader with information on the efficacy of PVA following VCF as well as the use of physical therapy intervention after PVA. It is hoped that this information will heighten awareness of the increasing use of surgical intervention for VCF and encourage physical therapists to identify the most appropriate interventions for the rehabilitation of individuals status post PVA.

METHODS

A search was conducted using Medline and the Cumulative Index of Nursing and Allied Health Literature (CINAHL) for the years between January 1990 and August 2005. Key words for the search included: vertebroplasty, kyphoplasty, physical therapy, rehabilitation, and outcomes. Additional searches were completed using the Physiotherapy Evidence Database (PEDro) and the Cochrane Database of Systematic Reviews (Cochrane Reviews), as well as the Agency for Healthcare Research and Quality (AHRQ): National Guideline Clearinghouse using key words vertebroplasty, kyphoplasty, and compression fracture.

Studies were initially reviewed by title and abstract. Inclusion criteria (Table 1) included whether the study was quantitative, available in English, and included physical therapy, rehabilitation, or functional outcomes compared over time following PVA secondary to osteoporotic VCF of the lumbar or thoracic spine in older adults.

Quality Scoring

A quality scoring system was developed to allow comparison of the articles. The quality scoring system was modeled after a study by Cleland and Durall[28] and consisted of data present (point given) or not present (point not given). The greater the number of scoring criteria present, the higher the number of points received by that article. The quality score (percentage) was calculated by dividing each article's points by the 20 points possible. Table 1 lists the criteria of the quality scoring system, and the percentage of articles satisfying each criterion. Table 2 provides the quality score assigned to each article.

RESULTS

No studies were found with searches on PEDro, Cochrane Reviews, or the AHRQ: National Guideline Clearinghouse. Searches in CINAHL and Medline resulted in 67 articles (21 and 53 respectively, with 7 duplicates) examining outcomes, rehabilitation, or physical therapy following PVA. After reviewing the title, description, abstract, or full text of the 67 articles, 36 were excluded because they were not research studies or lacked functional outcome measures. Seven studies were excluded because they focused on conditions other than VCF, and 6 were excluded because their focus was on surgical technique or specific surgical procedures. Three articles were excluded because they were case studies or literature reviews. One article was excluded because of the inconsistent use of assessments for subjects and another was excluded because only the abstract was available. Four additional articles, located through reference review, met the inclusion criteria and were used, bringing the total to 17 studies.

Of the 17 studies (Table 2), there were 10 prospective nonrandomized studies without a control group, 5 retrospective studies, and 2 prospective nonrandomized controlled trials. None of the studies was a randomized controlled trial. Table 3 provides data related to questions and variables, study design, sample size and profile, complications, and conclusions of each study.

Nonrandomized Controlled Trials

The prospective nonrandomized controlled trials by Kasperk et al[29] and Diamond et al[30] had a mean quality score of 73% (Table 4). Both studies included a control group and had greater than 30 subjects. Both studies employed multiple outcome assessments that focused on pain, function, and use of pain medication. Both studies described complications following PVA and 1 study reported fracture status and discharge information. Neither study measured psychological outcomes. Conservative treatment was attempted in 1 study; however, neither study addressed physical therapy intervention following PVA.

Table 1. Quality Scoring Criteria and Percentage of Studies Satisfying the Criteria

Criteria	Points if present	Studies satisfying criteria N (%)
Enrollment criteria included osteoporotic VCF	1	17/17 (100)
Mean age of subjects was ≥ 65 years	1	17/17 (100)
Number of subjects was ≥ 30	1	13/17 (76)
Included a control group	1	2/17 (12)
Identified subjects lost in the study	1	14/17 (82)
Outcome frequency: 1-2 weeks	1	10/17 (59)
> 2 months post	1	8/17 (47)
> 6 months	1	10/17 (59)
> 12 months	1	7/17 (41)
Outcome measured: Pain	1	17/17 (100)
Function	1	17/17 (100)
Psychological factors	1	9/17 (53)
Pain medication	1	9/17 (53)
Fracture status – new or old	1	7/17 (41)
Attempted conservative treatment	1	14/17 (82)
Test-retest performed by the same person	1	4/17 (24)
Included complications of PVA from study	1	15/17 (88)
Included information for discharge following PVA	1	9/17 (53)
Utilized statistical data	1	17/17 (100)
Identified limitations of the study	1	8/17 (47)
Total criteria points	20	

VCF=vertebral compression fracture
PVA=percutaneous vertebral augmentation
N=number of studies out of 17 possible

Retrospective Studies

The mean quality score for the 5 retrospective studies[31-35] was 63% (Table 4). All 5 studies had greater than 30 subjects, but lacked a control group. Four did not report psychological considerations, failed to mention discharge information, or did not include patients' fracture status. Three studies did not mention medication use or failed to identify who performed the outcome assessment. Two studies did not report study limitations. Only 3 studies completed multiple outcome assessments and included complications following PVA. Four studies reported use of conservative treatment prior to surgical intervention. None of the studies included physical therapy intervention following PVA.

Prospective Studies

The mean quality score for the 10 prospective nonrandomized studies without controls[36-45] was 66% (Table 4). All of the prospective studies measured pain, function, and described complications following PVA but lacked a control group. Four studies had less than 30 subjects. Eight studies did not mention who performed the outcome assessments and 7 studies did not report study limitations. Only 7 studies included multiple outcome assessments. Five studies did not mention medication use or include fracture status, and 2 had no information related to psychological assessments. Seven studies reported discharge information, and 9 studies used conservative treatment prior to surgical intervention; however, none of the studies included physical therapy intervention following PVA.

Outcomes of PVA

Based upon the 17 studies in this systematic literature review, overall outcomes following PVA are favorable. After

Table 2. Studies Included in this Systematic Review

Reference*	Type†	Quality Score (%)
Brown et al (2005)[32]	Vertebroplasty	65
Chen et al (2004)[42]	Vertebroplasty	65
Cortet et al (1999)[37]	Vertebroplasty	80
Coumans et al (2003)[39]	Kyphoplasty	65
Diamond et al (2003)[30]	Vertebroplasty	65
Do et al (2005)[38]	Vertebroplasty	80
Evans et al (2003)[31]	Vertebroplasty	70
Kasperk et al (2005)[29]	Kyphoplasty	80
Kaufmann et al (2001)[35]	Vertebroplasty	50
Ledlie and Renfro (2003)[33]	Kyphoplasty	65
Lieberman et al (2001)[43]	Kyphoplasty	60
Liliang et al (2005)[44]	Vertebroplasty	55
McGraw et al (2002)[40]	Vertebroplasty	65
McKiernan et al (2004)[41]	Kyphoplasty	65
Phillips et al (2003)[45]	Kyphoplasty	45
Rhyne et al (2004)[34]	Kyphoplasty	65
Zoarski et al (2002)[36]	Vertebroplasty	80

*References are listed in alphabetical order.
†Type of percutaneous vertebral augmentation (PVA) included in the study.

PVA, patients reported decreased pain[29-33,35-45] and medication use,[31,35,38,44] increased function,[29-33,35,36,39,40,43-45] and improved quality of life.[33,34,37-39,41] Decreased hospital stay[33] and fewer physician visits[29] were also reported. Mean hospital stay was 1.7 days for kyphoplasty with 82% of patients discharged to home, 11% to rehabilitation facilities, and 5% to skilled care centers.[33] Diamond et al described a 40% decrease in hospital stay for patients with vertebroplasty compared to those treated conservatively.[30] Most of the studies reported decreased pain following PVA[29-33,35-45] that was sustained over time.[36,40] The amount and type of medication used changed post PVA.[31,35,38,44] Medications typically used prior to PVA included narcotics and prescription non-narcotics, while medications used post PVA included fewer prescription non-narcotics and over-the-counter medications such as aspirin, acetaminophen, and nonsteroidal anti-inflammatory drugs.[38] Evans et al reported a substantial decrease in scheduled oral narcotics and other medications following PVA.[31] Diamond et al found that 25% of patients stopped all pain medications within 24 hours following vertebroplasty compared to no decease in pain medication for the control group.[30]

Kyphoplasty was reported to restore vertebral body height (VBH) by as much as 12% compared to an 8% decrease in VBH for individuals treated conservatively.[29] Lieberman et al reported that VBH was restored by an average of 35% following PVA.[43] Significant changes in VBH were also noted when measured radiographically, showing an average anterior VBH increase of 4.6 mm.[34] Even 1 year post PVA, anterior VBH remained at 85% of predicted levels, while midline VBH remained at 89% of predicted levels.[33]

Ambulation, physical function, and quality of life improved following PVA.[29-41,43-45] Evans et al reported that 18% of patients were bedridden and 55% were in wheelchairs or had limitations in ambulation prior to PVA.[31] Following PVA, 70% of patients had normal ambulation, and 63% were able to perform activities of daily living with little or no pain.[31] Improved physical function[44] and quality of life[41] were sustained 6 months post PVA. Diamond et al reported a 29% increase in physical function following vertebroplasty compared to no improvement in the control group.[30]

Fourteen studies reported complications following PVA.[29-31,33,34,36,37,39,40-45] Two studies did not address complications[32,35] and Do et al reported that no complications occurred as a result of PVA.[38] Cement leakage was the most common complication following PVA.[29,31,34,36,37,39-44] Results of cement leakage varied from no symptoms,[34,36,37,39,41,43] to radiculopathy,[31,40,44] and lower limb paresis.[29] Chen et al reported the need for surgical decompression due to cement leakage.[42] Additional fractures were noted in 4 studies[30,31,34,41] including vertebral compression fractures, and fractures of transverse processes and ribs. Other medical complications, not directly related to PVA, included myocardial infarction,[39,43,45] pulmonary embolism,[33,36] and exacerbation of medical conditions such as congestive heart failure and pulmonary edema.[43,45]

While the 17 studies demonstrated the effectiveness of PVA, there was little consistency in discharge criteria following the procedure. In some studies, patients were discharged based upon a specific time frame.[29,36,37,39,42,44] Two studies based discharge upon patient status.[31,38] Evans et al reported immobilization for 1 hour following PVA with discharge once patients could ambulate[31] and Do et al discharged patients when medically stable.[38] McGraw et al used positioning and time as a reference for progressing the patient prior to discharge.[40] They observed the patient in supine for 1 hour, in sitting for 1 hour, and then allowed the patient to stand; however, did not specify a time frame for discharge.[40] Chen et al discharged patients with a thoracolumbar support within 24 hours following PVA.[42] Other authors described discharge based upon time including 3 hours,[36] overnight observation,[44,45] or 48 hours[29] as the guide. One study kept patients supine for 24 hours and discharged them 3 days after PVA.[37]

None of the 17 studies mentioned physical therapy intervention following PVA; however, patients may have received physical therapy intervention prior to discharge. Nine studies described discharge information; although there was no consistency between studies, nor was there a reference to physical therapy intervention that may have affected the outcomes of PVA.[29,31,36-40,42,44] One study required that patients attain a predetermined functional level prior to discharge but did not indicate that physical therapy intervention was provided.[31]

DISCUSSION

The purpose of this systematic literature review was to present a summary of research findings regarding the efficacy of PVA and the incorporation of physical therapy intervention following PVA. All of the studies in this systematic review supported the use of kyphoplasty or vertebroplasty; however, none recommended PVA be used in place of conservative treatment. None of the studies evaluated discussed the incorporation of physical therapy intervention following PVA.

Efficacy of PVA

Conservative treatment for VCF may be effective; however, when bed rest, bracing, and analgesics do not provide pain relief, there is growing evidence to support PVA. Fourteen studies attempted conservative treatment but when conservative treatment failed to provide symptom relief, PVA was performed.[29,31-34,36-38,40-45] Patients with limited progress following conservative treatment may find pain relief following PVA, thus improving functional mobility and quality of life. Two studies, excluded from this review because they did not examine functional outcomes, reported that PVA decreased pain and was a safe and effective procedure.[46,47] These results are consistent with the studies included in this review. Lower levels of pain may lead to decreased medication use, encouraging earlier

Table 3. Summary of Studies Reviewed (the articles are grouped according to study design and are listed in reverse chronological order)

	Study	Questions and variables	Sample size and profile	Complications	Conclusions
Nonrandomized Trials	Kasperk et al (2005)[29]	Evaluate the effects of kyphoplasty on pain and mobility in patients with chronic pain from VCF Follow-up frequency: 24 hrs to 6 months Outcomes measured: pain level, medication use, function, health contacts, new fractures	Mean age = 69.2 years (34-85) N = 60 (40 Surgery, 20 Control) 105 fractures surgically treated	Spinal cord penetration with leg paresis, epidural hematoma	Kyphoplasty increased vertebral height, improved mobility, decreased pain, and led to fewer physician visits
	Diamond et al (2003)[309]	Determine if PVA is an effective treatment for VCF Follow-up frequency: 24 hrs to 12 months Outcomes measured: pain level, medication use, function	Mean age = 76.4 years (51-93) N = 79 (55 Surgery, 24 Control) 71 fractures surgically treated	2 patients with fractured transverse processes, 1 patient hemorrhaged into psoas; 3 patients with additional fractures in non-adjacent vertebrae within 6 weeks	Compared to conservative therapy, PVA provided prompt pain relief and rapid rehabilitation; safe and well tolerated by patients
Retrospective Studies	Brown et al (2005)[32]	Correlate pre-PVA MRI with outcomes Follow-up frequency: 2 wks to 12 months Outcomes measured: pain level, mobility	Mean age = 70 years (30-87) N = 45 94 fractures surgically treated	No report of complications	PVA decreased pain and increased mobility, 80% of patients with fractures older than 1 year experienced clinical benefit
	Rhyne et al (2004)[34]	Document initial outcomes following PVA Follow-up frequency: 2 wks to 9 months Outcomes measured: pain level, disability, vertebral height	Mean age = 74 years (49-89) N = 52 82 fractures surgically treated	10% experienced cement leakage with no symptoms; 13.5% experienced subsequent fracture	PVA safely increased vertebral body height and improved patient QOL
	Evans et al (2003)[31]	Describe immediate outcomes following PVA Follow-up frequency: 7 months Outcomes measured: pain level, medication use, ADLs and ambulation, disability	Mean age = 76 years (44-98) N = 245 554 fractures surgically treated	7 rib fractures within 24 hours, radicular pain, 3 subjects with increased pain due to unknown cause	PVA appeared safe, medication use decreased substantially, and function improved
	Ledlie and Renfro (2003)[33]	Assess safety and evaluate outcomes related to pain and activity level Follow-up frequency: 1 wk to 12 months; Outcomes measured: pain level, ambulation, vertebral height	Mean age = 76 (51-93) N = 96 133 fractures surgically treated	Ventilator required post surgery, pulmonary embolism experienced 2 wks post surgery	PVA decreased pain, increased vertebral height, improved activity level and QOL
	Kaufmann et al (2001)[35]	Determine correlation between age of fracture prior to surgery and pain, mobility, and medication usage Follow-up frequency: 1 month Outcomes measured: pain level, mobility, medication use	Mean age = 74 years (40-92) N = 75 122 fractures surgically treated	No report of complications	PVA decreased pain and medication use, increased activity independent of fracture age

Table 3. Continued.

Prospective Studies	Do et al (2005)[38]	Effect of PVA on mobility, pain, analgesic use, and QOL Follow-up frequency: 1 month to 36 months Outcomes measured: pain, medication use, mobility, QOL	Mean age = 74.6 years N = 167 264 fractures surgically treated	Reported no complications	PVA significantly decreased pain and medication use, improved mobility, and demonstrated short and long-term QOL improvement
	Liliang et al (2005)[44]	Efficacy of PV in treating osteoporotic VCF Follow-up frequency: 24 hr to 6 months Outcomes measured: pain, medication use, function	Mean age = 77 years (69-85) N = 16 22 fractures surgically treated	25% of subjects experienced cement leakage, 1 subject experienced radiculopathy treated with steroids and analgesics	PV was safe and effective for use in the elderly with decreased pain intensity and medication use as well as improved physical function
	Chen et al (2004)[42]	Assess efficacy and safety of PV for treatment of pain due to osteoporotic VCF Follow-up frequency: 1 day to 1 year Outcomes measured: pain, QOL, mobility	Mean age = 70.2 years (62-91) N = 75 87 fractures surgically treated	38% of subjects experienced cement leakage, 1 required decompression	PV provided significant pain relief, there was decreased cement leakage with skill and use of safeguards
	McKiernan et al (2004)[41]	Assess outcomes of pain and QOL following PV Follow-up frequency: 2 wks to 6 months Outcomes measured: pain, QOL	Mean age = 74.3 years (47-91) N = 49 66 fractures surgically treated	15% of subjects experienced cement leakage with no symptoms, 6.5% of subjects had additional VCF	PV provided rapid pain relief, improved QOL, with no apparent increase in fracture
	Coumans et al (2003)[39]	Compare outcomes related to pain, disability, and QOL Follow-up frequency: 3 weeks to 24 months Outcomes measured: pain, QOL, disability, function	Mean age = 71 years (44-89) N = 78 188 fractures surgically treated	Myocardial infarction from fluid overload, 5 cases of cement leakage – no symptoms	PVA decreased pain, improved physical function and social health
	Phillips et al (2003)[45]	Study of clinical and radiological outcomes after kyphoplasty Follow-up frequency: 1 week to 12 months Outcomes measured: pain, medication use, function, vertebral height, Patient satisfaction	Mean age = 70 years N = 29 61 fractures surgically treated	Myocardial infarction experienced by 1 subject, 1 subject experienced exacerbation of CHF along with atrial fibrillation	Kyphoplasty decreased kyphotic deformity, decreased pain, improved physical function with a low risk of complications
	McGraw et al (2002)[40]	Determine efficacy and durability of PV for treatment of back pain due to VCF Follow-up frequency: 12-24 hours to 21.5 months Outcomes measured: pain, medication use, ambulation, QOL	Mean age = 73.7 years (37-94) N = 100 156 fractures surgically treated	Transient radiculopathy, sternal fracture experienced by subject trying to transfer self before procedure	PV restored mobility and provided immediate and extended pain relief
	Zoarski et al (2002)[36]	Assess long-term safety and efficacy of PVA Follow-up frequency: 2 wks to 18 months Outcomes measured: pain level, QOL, disability, patient satisfaction	Mean age = 79 years (57-90) N = 30 54 fractures surgically treated	Epidural leak without symptoms, pulmonary embolism 6 days post surgery with complete recovery	PVA provided immediate safe and long-term relief of pain and disability
	Lieberman et al (2001)[43]	Evaluate the safety and efficacy of kyphoplasty Follow-up frequency: 1 week to 6.7 months Outcomes measured: pain, function, vertebral height	Mean age = 68.6 years (48-86) N = 30 70 fractures surgically treated	Cement leakage at six levels with no symptoms, pulmonary edema and myocardial infarction experienced due to fluid overload	Kyphoplasty restored vertebral height, decreases pain, improved function
	Cortet et al (1999)[37]	Assess safety and efficacy of PV for treatment of pain due to osteoporotic VCF Follow-up frequency: 3 days to 180 days Outcomes measured: pain, QOL	Mean age = 66 years (47-79) N = 16 20 fractures surgically treated	65% of subjects experienced cement leakage with no clinically relevant side effects noted	PV led to fast and marked pain relief, favorable influence on QOL

Abbreviations: VCF = Vertebral compression fracture; PVA = Percutaneous vertebral augmentation; PV = Percutaneous vertebroplasty; QOL = Quality of life ADLs = Activities of daily living

Table 4. Scoring Criteria

Criteria*	Nonrandomized Controlled Trials			Retrospective Studies						Prospective Studies									
	Kasperk et al (2005)[29]	Diamond et al (2003)[30]		Evans et al (2003)[31]	Ledlie and Renfro (2003)[33]	Rhyne et al (2004)[34]	Brown et al (2005)[32]	Kaufman et al (2001)[35]		Zoarski et al (2002)[36]	Cortet et al (1999)[37]	Do et al (2005)[38]	Coumans et al (2003)[39]	McGraw et al (2002)[40]	McKiernan et al (2004)[41]	Chen et al (2004)[42]	Lieberman et al (2001)[43]	Liliang et al (2005)[44]	Phillips et al (2003)[45]
Enrollment criteria included osteoporotic VCF	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Mean age of subjects was at least 65 years	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Number of subjects 30 or greater	1	1		1	1	1	1	1		1	0	1	1	1	1	1	0	0	0
Included a control group	1	1		0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
Identified subjects lost in the study	1	1		1	1	1	0	1		1	1	1	1	1	0	1	1	1	0
Outcome frequency: 1-2 weeks	0	1		0	1	0	1	1		1	0	1	0	0	1	1	1	0	1
> 2 months	1	0		0	1	1	1	0		0	1	0	1	0	1	0	1	0	0
> 6 months	1	1		1	1	1	1	0		0	1	1	0	0	1	0	0	1	0
> 12 months	0	0		0	1	0	1	0		1	0	1	1	1	0	0	0	0	1
Outcome measured: Pain	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Function	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Psychological factors	0	0		1	0	0	0	0		1	1	1	1	1	1	1	1	0	0
Pain medication	1	1		1	0	0	0	1		1	1	1	0	1	0	0	0	1	0
Fracture status – new or old	1	0		0	0	1	0	0		1	1	0	1	0	1	1	0	0	0
Attempted conservative treatment	1	0		1	1	1	1	0		1	1	1	0	1	1	1	1	1	1
Test-retest by the same person	0	0		0	0	1	1	0		0	1	0	0	0	0	0	1	0	0
Included complications of PVA study	1	1		1	1	1	0	0		1	1	1	1	1	1	1	1	1	1
Included discharge information following PVA	1	0		1	0	0	0	0		1	1	1	1	1	0	1	0	1	0
Utilized statistical data	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Identified limitations of the study	1	1		1	0	0	1	1		1	1	1	0	0	0	0	0	0	0
Total criteria points/20 possible points	16	13		14	13	13	13	10		16	16	16	13	13	13	13	12	11	9
Quality Score†	80	65		70	65	65	65	50		80	80	80	65	65	65	65	60	55	45
Mean Quality Score†	73			63						66									

*Criteria: 1 = present in study; 0 = not present in study

†Mean = %

VCF=vertebral compression fracture, PVA=percutaneous vertebral augmentation

return to function and preventing further debilitation and secondary complications of immobility.[9,10,12]

Although the evaluated studies supported the use of PVA, some concerns were noted when PVA was used during the acute stage following VCF. Treating acute fractures with PVA increased the risk for cement leakage; therefore, it was recommended that surgical intervention be withheld until the subacute stage.[48,49] However, the time necessary for conservative treatment may lead to secondary complications from bed rest and immobility.[18,19,24] Prolonged pain, immobility, and limited function present during conservative treatment can lead to molecular changes in bone and cardiorespiratory compromise.[9,50] When PVA is finally performed, the patient's status may have already deteriorated.

The complications following PVA described in this systematic review were similar to complications reported in studies that did not meet our inclusion criteria. The most commonly reported complication following vertebroplasty and kyphoplasty was cement leakage.[51] Deramond et al reported increased incidence of cement leakage that was related to destruction of the vertebral body.[24] According to Gafin et al, there is more risk of leakage with vertebroplasty than kyphoplasty.[51] Bone cement leakage was reported in 30% to 67% of patients following vertebroplasty but less than 1% to 10% leakage with kyphoplasty.[51,52] Few patients were found to be symptomatic with either procedure.[46,51]

Additional complications, identified in the literature describing surgical techniques, were not reported in the 17

studies evaluated in this systematic review. In addition to complications of PVA such as increased pain and rib or vertebral fracture, other studies identified hemorrhage, fever, and infection as complications.[4,46,47,51] While PVA is reported to be a safe and effective treatment, it is important to note that serious complications, such as pneumothorax, radiculopathy or spinal cord compression, and cement pulmonary embolism, have occurred in 1% to10% of cases.[4,7,24,51,53,54] Uppin et al reported an increased incidence of VCF following PVA, with 22 of 177 patients (12.4%) experiencing additional VCF.[55] Two-thirds of these fractures occurred in vertebrae adjacent to cemented vertebrae.[55]

Physical Therapy Intervention Following PVA

With limited data available regarding discharge criteria and rehabilitation following PVA, evidence-based practice guidelines have not been developed. Physical therapists are specifically qualified to develop guidelines for patients with VCF, whether or not they have undergone PVA. Specific practice patterns supporting intervention after PVA already exist in the *Guide to Physical Therapist Practice* and include *Musculoskeletal Patterns*: 4B- Impaired Posture and 4G- Impaired Joint Mobility, Muscle Performance, and Range of Motion Associated with Fracture.[56]

While physical therapy intervention following PVA was not discussed in the literature, studies were found that provide a framework for program development.[4,10,12] In some studies, movement and physical activity were allowed between 2 and 24 hours post PVA.[4,10] Larsen reported that dressings could be removed 24 hours after PVA and patients could bathe or shower the following day.[12] According to Spivak and Johnson, intervention following PVA should include exercises for spinal extension once pain allows.[57] Specific exercises for postural improvement through strengthening trunk extension are reported in the literature.[58,59]

Implications for Research

Of the 17 studies included in this systematic review, only 2 had a control group.[29,30] Both control groups consisted of individuals who declined surgical intervention. Although the control and intervention groups were not matched, both studies described characteristics that were similar between groups. Because of the limited number of studies and the absence of randomized controlled trials related to outcomes following PVA, the results and conclusions of the studies in this systematic review may be limited. Randomized controlled trials should be developed to examine the difference between conservative treatment and PVA. The long-term effects of PVA are not yet known. The longest follow-up study was completed by Perez-Higueras et al who found that pain reduction was still significant 5 years postsurgical intervention.[46] Longitudinal studies should be completed to determine the long-term efficacy of PVA.

Studies should compare the outcomes of patients receiving physical therapy intervention following VCF, whether treated conservatively or with PVA, with those receiving no physical therapy intervention. Outcome measures could include measures of spinal posture as well as pain, physical function, medication use, and quality of life. Kyphotic posture negatively affects patients' balance, respiratory status, and risk for falls and future VCF.[8,9] Using a reliable device to measure posture would allow comparison of posture before and after PVA, as well as before and after conservative treatment for VCF. Kyphotic curve could be measured using the flexi-curve,[60-63] index of kyphosis,[61] curviscope,[64] Arcometer,[65] or mid-sagittal contour gauge.[66] Respiratory status could be assessed by measuring vital capacity and forced expiratory volume using a portable spirometer, allowing correlation between PVA, posture, and respiratory function.

Limitations

This systematic review has several limitations. The search was limited to articles in English and only included 5 databases (Cochrane Reviews, AHRQ: National Guideline Clearinghouse, PEDro, Medline, and CINAHL). While a meta-analysis would be the ideal statistical tool to compare studies, it was not used in this systematic review due to differences and variability in outcomes measured. Another limitation was the use of a quality scoring system to rank the studies. Such a system has been used by other authors to compare studies with variable outcomes or interventions.[28,67] The quality scoring system used in this review allowed the 17 studies to be scored and compared. In order to improve consistency, the same investigator determined the absence or presence of scoring criteria for all studies. Additionally, all criteria were weighted equally, thus the importance of each criterion was not quantified. For example, even though 2 studies had control groups, with assigned quality scores of 65%[30] and 80%,[29] other studies[36-38] scored 80% without the inclusion of a control group. The use of a weighted quality scoring system may be useful in future reviews.

CONCLUSION

Although PVA appears to be an effective treatment option for individuals with VCF, further research regarding the use and long term outcomes of PVA would be beneficial. Presently physical therapy is not a standard treatment intervention following PVA. Whether outcomes following PVA might be enhanced with the provision of physical therapy intervention warrants investigation.

REFERENCES

1. Lin JT, Lane JM. Osteoporosis: a review. *Clin Orthop.* 2004;425:125-134.
2. Wu SS, Lachmann E, Nagler W. Current medical, rehabilitation, and surgical management of vertebral compression fractures. *J Womens Health*. 2003;12:17-26.
3. Lukert BP. Vertebral compression fractures: how to manage pain, avoid disability. *Geriatrics*. 1994;49:22-26.
4. Predey TA, Sewall LE, Smith SF. Percutaneous vertebroplasty: new treatment for vertebral compression fractures. *Am Fam Physician*. 2002;66:611-615.
5. Jarvik JG, Kallmes DF, Mirza SK. Vertebroplasty: learning more, but not enough. *Spine*. 2003;28:1487-1489.

6. Osteoporosis Prevention, Diagnosis, and Therapy. NIH Consensus Statement Online 2000 March 27-29;17:1-36. Available at: http://consensus.nih.gov/2000/2000Osteoporosis111html.htm. Accessed July 24, 2003.
7. Watts NB. Is percutaneous vertebral augmentation (vertebroplasty) effective treatment for painful vertebral fractures? *Am J Med*. 2003;114:326-328.
8. Lombardi I Jr, Oliveira LM, Mayer AF, Jardim JR, Natour J. Evaluation of pulmonary function and quality of life in women with osteoporosis. *Osteoporos Int*. 2005;16:1247-1253.
9. Haczynski J, Jakimiuk AJ. Vertebral fractures: a hidden problem of osteoporosis. *Med Sci Monit*. 2001;7:1108-1117.
10. Ensrud KE, Thompson DE, Cauley JA, et al. Prevalent vertebral deformities predict mortality and hospitalization in older women with low bone mass. *J Am Geriatr Soc*. 2000;48:241-249.
11. Deen HG, Fenton DS, Lamer TJ. Minimally invasive procedures for disorders of the lumbar spine. *Mayo Clin Proc*. 2003;78:1249-1256.
12. Larsen D. Percutaneous vertebroplasty. *Nurs Stand*. 2004;18:33-37.
13. Old JL. Vertebral compression fractures in the elderly. *Am Fam Physician*. 2004;69:111-116.
14. Schlaich C, Minne HW, Bruckner T, et al. Reduced pulmonary function in patients with spinal osteoporotic fractures. *Osteoporos Int*. 1998;8:261-267.
15. Lieberman IH. Spine specialists on-call: osteoporotic vertebral compression fractures–restoring spinal stability and quality of life. Available at: http://www.spineuniverse.com. Accessed January 5, 2005.
16. Truumees E, Hilibrand A, Vaccaro AR. Contemporary concepts review: percutaneous vertebral augmentation. *Spine J*. 2004;4:218-229.
17. Kim DH, Silber JS, Albert TJ. Osteoporotic vertebral compression fractures. *Instr Course Lect*. 2003;52:541-550.
18. Rao RD, Singrakhia MD. Painful osteoporotic vertebral fracture. *J Bone Joint Surg Am*. 2003;85:2010-2022.
19. Tamayo-Orozco J, Arzac-Palumbo P, Peon-Vidales H, Mota-Bolfeta R, Fuentes F. Vertebral fractures associated with osteoporosis: patient management. *Am J Med*. 1997;103:44S-50S.
20. Frost HM. Personal experience in managing acute compression fractures, their aftermath, and the bone pain syndrome, in osteoporosis. *Osteoporos Int*. 1998;8:13-15.
21. Rapado A. General management of vertebral fractures. *Bone*. 1996;18:191S-196S.
22. Mehbod A, Aunoble S, Le Huec JC. Vertebroplasty for osteoporotic spine fracture: prevention and treatment. *Eur Spine J*. 2003;12:S155-S162.
23. Mathis JM, Wong W. Percutaneous vertebroplasty: technical considerations. *J Vasc Interv Radiol*. 2003;14:953-960.
24. Deramond H, Depriester C, Galibert P, Le Gars D. Percutaneous vertebroplasty with polymethylmethacrylate: techniques, indications, and results. *Radiol Clin North Am*. 1998;36:533-546.
25. Papaioannou A, Watts NB, Kendler DL, Yuen CK, Adachi JD, Ferko N. Diagnosis and management of vertebral fractures in elderly adults. *Am J Med*. 2002;113:220-228.
26. Mathis JM, Oritz AO, Zoarski GH. Vertebroplasty versus kyphoplasty: a comparison and contrast. *AJNR Am J Neuroradiol*. 2004;25:840-845.
27. Garfin SR, Reilley MA. Minimally invasive treatment of osteoporotic vertebral body compression fractures. *Spine J*. 2002;2:76-80.
28. Cleland J, Durall CJ. Physical therapy for adhesive capsulitis: systematic review. *Physiotherapy*. 2002;88:450-457.
29. Kasperk C, Hillmeier J, Noldge G, et al. Treatment of painful vertebral fractures by Kyphoplasty in patients with primary osteoporosis: a prospective nonrandomized controlled study. *J Bone Miner Res*. 2005;20:604-612.
30. Diamond TH, Champion B, Clark WA. Management of acute osteoporotic vertebral fractures: a nonrandomized trial comparing percutaneous vertebroplasty with conservative treatment. *Am J Med*. 2003;114:257-265.
31. Evans AJ, Jensen ME, Kip KE, et al. Vertebral compression fractures: pain reduction and improvement in functional mobility after percutaneous polymethylmethacrylate vertebroplasty – retrospective report of 245 cases. *Radiology*. 2003;226:366-372.
32. Brown DB, Glaiberman CB, Gilula LA, Shimony JS. Correlation between preprocedural MRI findings and clinical outcomes in the treatment of chronic symptomatic vertebral compression fractures with percutaneous vertebroplasty. *AJR Am J Roentgenol*. 2005;184:1951-1955.
33. Ledlie JT, Renfro M. Balloon kyphoplasty: one-year outcomes in vertebral body height restoration, chronic pain, and activity levels. *J Neurosurg Spine*. 2003;98(Suppl):36-42.
34. Rhyne A III, Banit D, Laxer E, Odum S, Nussman D. Kyphoplasty: report of eighty-two thoracolumbar osteoporotic vertebral fractures. *J Orthop Trauma*. 2004;18:294-299.
35. Kaufmann TJ, Jensen ME, Schweickert PA, Kallmes DF. Age of fracture and clinical outcomes of percutaneous vertebroplasty. *AJNR Am J Neuroradiol*. 2001;22:1860-1863.
36. Zoarski GH, Snow P, Olan WJ, et al. Percutaneous vertebroplasty for osteoporotic compression fractures: quantitative prospective evaluation of long-term outcomes. *J Vasc Interv Radiol*. 2002;13:139-148.
37. Cortet B, Cotton A, Boutry N, et al. Percutaneous vertebroplasty in the treatment of osteoporotic vertebral compression fractures: an open prospective study. *J Rheumatol*. 1999;26:2222-2228.
38. Do HM, Kim BS, Marcellus ML, Curtis L, Marks MP. Prospective analysis of clinical outcomes after percutaneous vertebroplasty for painful osteoporotic vertebral body fractures. *AJNR Am J Neuroradiol*. 2005;26:1623-1628.
39. Coumans JV, Reinhardt MK, Lieberman IH. Kyphoplasty for vertebral compression fractures: 1-year clinical outcomes from a prospective study. *J Neurosurg Spine*. 2003;99:44-50.

40. McGraw JK, Lippert JA, Minkus KD, Rami PM, Davis TM, Budzik RF. Prospective evaluation of pain and relief of 100 patients undergoing percutaneous vertebroplasty: results and follow-up. *J Vasc Interv Radiol*. 2002;13:883-886.
41. McKiernan F, Faciszewski T, Jensen R. Quality of life following vertebroplasty. *J Bone Joint Surg Am*. 2004;86A:2600-2606.
42. Chen LH, Niu CC, Yu SW, Fu TS, Lai PL, Chen WJ. Minimally invasive treatment of osteoporotic vertebral compression fracture. *Chang Gung Med J*. 2004;27:261-267.
43. Lieberman IH, Dudeney S, Reinhardt MK, Bell G. Initial outcome and efficacy of "kyphoplasty" in the treatment of painful osteoporotic vertebral compression fractures. *Spine*. 2001;26:1631-1638.
44. Liliang PC, Su TM, Liang CL, Chen HJ, Tsai YD, Lu K. Percutaneous vertebroplasty improves pain and physical functioning in elderly osteoporotic vertebral compression fracture patients. *Gerontology*. 2005;51:34-39.
45. Phillips FM, Ho E, Campbell-Hupp M, McNally T, Wetzel FT, Gupta P. Early radiographic and clinical results of balloon kyphoplasty for the treatment of osteoporotic vertebral compression fractures. *Spine*. 2003;28:2260-2267.
46. Perez-Higueras A, Alvarez L, Rossi RE, Quinones D, Al-Assir I. Percutaneous vertebroplasty: long-term clinical and radiological outcome. *Neuroradiology*. 2002;44:950-954.
47. Grados F, Depriester C, Cayrolle G, Hardy N, Deramond H, Fardellone P. Long-term observations of vertebral osteoporotic fractures treated by percutaneous vertebroplasty. *Rheumatology*. 2000;39:1410-1414.
48. Yu SW, Lee PC, Ma CH, Chuang TY, Chen YJ. Vertebroplasty for the treatment of osteoporotic compression spinal fracture: comparison of remedial action at different stages of injury. *J Trauma*. 2004;56:629-632.
49. Crandall D, Slaughter D, Hankins PJ, Moore C, Jerman J. Acute versus chronic vertebral compression fractures treated with kyphoplasty: early results. *Spine J*. 2004;4:418-424.
50. Phillips FM, Pfeifer BA, Lieberman IH, Kerr EJ III, Choi IS, Pazianos AG. Minimally invasive treatments of osteoporotic vertebral compression fractures: vertebroplasty and kyphoplasty. *Instr Course Lect*. 2003;52:559-567.
51. Garfin SR, Yuan HA, Reiley MA. New technologies in spine: kyphoplasty and vertebroplasty for the treatment of painful osteoporotic compression fractures. *Spine*. 2001;26:1511-1515.
52. Lieberman I, Reinhardt MK. Vertebroplasty and kyphoplasty for osteolytic vertebral collapse. *Clin Orthop*. 2003;415S: S176-S186.
53. Lane JM, Johnson CE, Khan SN, Girardi FP, Cammisa FP Jr. Minimally invasive options for the treatment of osteoporotic vertebral compression fractures. *Orthop Clin North Am*. 2002;33:431-438.
54. National Institute for Clinical Excellence (NICE). *Interventional procedure guidance 12: percutaneous vertebroplasty*. London; 2003. Available at: http://www.nice.org.uk. Accessed April 7, 2005.
55. Uppin AA, Hirsch JA, Centenera LV, Pfiefer BA, Pazianos AG, Choi IS. Occurrence of new vertebral body fracture after percutaneous vertebroplasty in patients with osteoporosis. *Radiology*. 2003;226:119-124.
56. *Guide to Physical Therapist Practice*. 2nd ed. Alexandria, Vs: American Physical Therapy Association; 2001.
57. Spivak JM, Johnson MG. Percutaneous treatment of vertebral body pathology. *J Am Acad Orthop Surg*. 2005;13:6-17.
58. Sanaki M, Mikkelson B. Postmenopausal spinal osteoporosis: flexion versus extension exercises. *Arch Phys Med Rehabil*. 1984;68:593-596.
59. Meeks S. *Walk Tall: An Exercise Program for the Prevention and Treatment of Osteoporosis*. Gainesville, Fla: Triad Publishing; 1999.
60. Anderson JA, Sweetman BJ. A combined flexi-rule/hydrogoniometer for measurement of lumbar spine and its sagittal movement. *Rheumatol Rehabil*. 1975;14:173-179.
61. Cutler WB, Freidman E, Genovese-Stone E. Prevalence of kyphosis in a healthy sample of pre- and postmenopausal women. *Am J Phys Med Rehabil*. 1993;72:219-25.
62. Rheault W, Ferris S, Foley JA, Schaffhauser D, Smith R. Intertester reliability of the flexible ruler for the cervical spine. *J Orthop Sports Phys Ther*. 1989;10:254-256.
63. Hart DL, Rose SJ. Reliability of a noninvasive method for measuring the lumbar curve. *J Orthop Sports Phys Ther*. 1986;8:180-184.
64. Cortet B, Houvenagel E, Puisieux F, Roches E, Garnier P, Delcambre B. Spinal curvatures and quality of life in women with vertebral fractures secondary to osteoporosis. *Spine*. 1999;24:1921.
65. D'Osualdo F, Schierano S, Iannis M. Validation of clinical measurement of kyphosis with a simple instrument, the arcometer. *Spine*. 1997;22:408-413.
66. Landers M, Barker G, Wallentine S, McWhorter JW, Peel C. A comparison of tidal volume, breathing frequency, and minute ventilation between two sitting postures in healthy adults. *Physiother Theory Pract*. 2003;19:109-119.
67. Van der Heijin GJMG, Ven der Windt DAWM, Winter AF. Physiotherapy for patients with soft tissue disorder: a systematic review of randomized clinical trials. *BMJ*. 1997;315:25-29.

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