

WASHINGTON STATE HEALTH CARE AUTHORITY

Appendices for Vertebroplasty, Kyphoplasty and Sacroplasty

Health Technology Assessment

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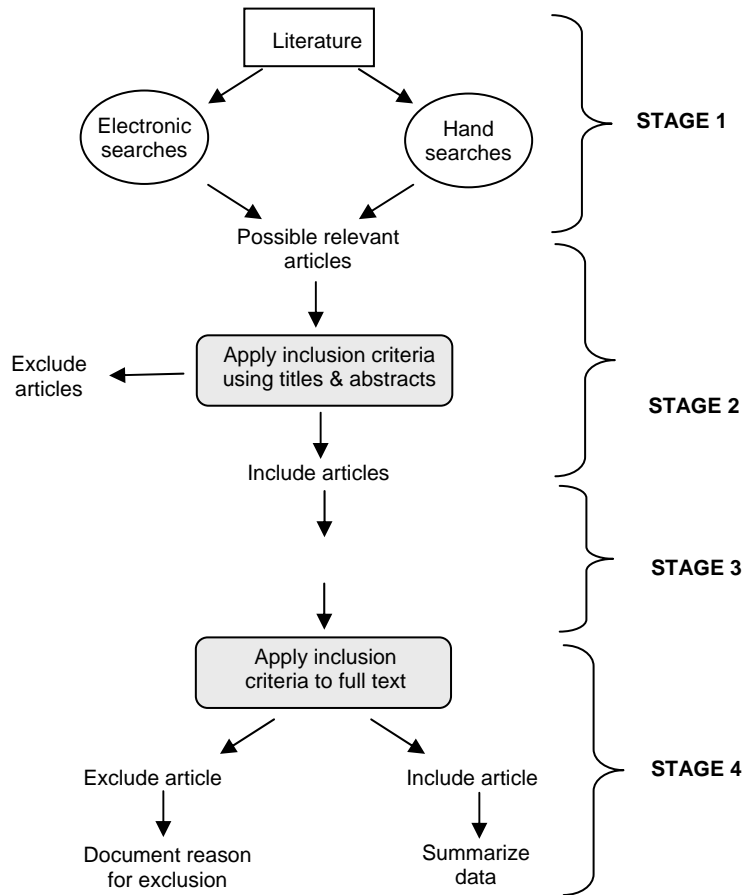
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APPENDIX A: ALGORITHM FOR ARTICLE SELECTION



APPENDIX B: SEARCH STRATEGIES

Database: MEDLINE

Vertebroplasty, kyphoplasty, or sacroplasty

#1	Search vertebroplast* OR kyphoplast* OR sacroplast* OR vesselplast* OR skyphoplast* OR vertebral augmentation
#2	Search (#1)NOT Comment[Publication Type]NOT Case reports[Publication Type] NOT Review[Publication Type] NOT Meta-analysis[Publication Type] NOT Editorial[Publication Type]
#3	Search (#2) NOT cadaver*
#4	Search (#2) NOT cadaver* Limits: only items with abstracts, English
#7	Search (#4)AND "2008/01/01"[Publication Date] : "3000"[Publication Date] Limits: only items with abstracts, English

Cost effectiveness

#1	Search vertebroplast* OR kyphoplast* OR sacroplast* OR vesselplast* OR skyphoplast* OR percutaneous vertebral augmentation OR cement augmentation
#2	Search ((#1) AND (economic OR cost OR cost-effectiveness))
#3	Search (((#1) AND (economic OR cost OR cost-effectiveness OR cost-benefit) Limits: only items with abstracts, English
	Search (((#1) AND (economic OR cost OR cost-effectiveness OR cost-benefit) NOT cadaver*

Safety

#1	Search vertebroplast* or kyphoplast* or sacroplast*
#2	Search (#1) AND (safety or complication or complications or adverse)
#3	Search (#1) AND (safety or complication or complications or adverse) Limits: only items with abstracts, English
#4	Search (#3) not cadaver* not sheep Limits: only items with abstracts, English
#5	Search (#4) NOT Case reports[Publication Type] NOT review[Publication Type] NOT editorial[Publication Type] NOT comment[Publication Type] Limits: only items with abstracts, English
#6	Search (#5) and "2006/12/01"[Publication Date] : "3000"[Publication Date] Limits: only items with abstracts, English
#8	Search (#1) Limits: only items with abstracts, English
#9	Search (#1) and (cement leakage) Limits: only items with abstracts, English
#10	Search (#9) NOT Case reports[Publication Type]) NOT review[Publication Type] NOT editorial[Publication Type] NOT comment[Publication Type] Limits: only items with abstracts, English
#11	Search (#10) and "2006/12/01"[Publication Date] : "3000"[Publication Date] Limits: only items with abstracts, English
#12	Search (#8) and (embolism) Limits: only items with abstracts, English
#13	Search (#12) NOT Case reports[Publication Type] NOT review[Publication Type] NOT editorial[Publication Type] NOT comment[Publication Type] Limits: only

	items with abstracts, English
#14	Search (#13) and "2006/12/01"[Publication Date] : "3000"[Publication Date] Limits: only items with abstracts, English
#15	Search (#8) and ((adjacent fracture) or (new fracture) or (subsequent fracture)) Limits: only items with abstracts, English
#16	Search (#15) NOT Case reports[Publication Type] NOT review[Publication Type] NOT editorial[Publication Type] NOT comment[Publication Type] Limits: only items with abstracts, English
#17	Search (#16) and "2006/12/01"[Publication Date] : "3000"[Publication Date] Limits: only items with abstracts, English

Parallel strategies were used to search the Cochrane Library, EMBASE and others listed below. Keyword searches were conducted in the other listed resources.

Electronic Database Searches

The following databases have been searched for relevant information:

Agency for Healthcare Research and Quality (AHRQ)
 Cumulative Index to Nursing and Allied Health (CINAHL)
 Cochrane Database of Systematic Reviews
 Cochrane Registry of Clinical Trials (CENTRAL)
 Cochrane Review Methodology Database
 Database of Reviews of Effectiveness (Cochrane Library)
 EMBASE
 PubMed
 Informational Network of Agencies for Health Technology Assessment (INAHTA)
 NHS Economic Evaluation Database
 HSTAT (Health Services/Technology Assessment Text)
 EconLIT

Additional Economics, Clinical Guideline and Gray Literature Databases

AHRQ □ Healthcare Cost and Utilization Project
 Canadian Agency for Drugs and Technologies in Health
 Centers for Medicare and Medicaid Services (CMS)
 Food and Drug Administration (FDA)
 Google
 Institute for Clinical Systems Improvement (ICSI)
 National Guideline Clearinghouse

APPENDIX C: EXCLUDED ARTICLES

Articles excluded at full-text review:

Author	Reason for exclusion
Choe	Insufficient information to evaluate
Masala	Insufficient information to evaluate
Mudano	Analysis of administrative database
Muto	>10% traumatic fractures in sample
Nussbaum	Analysis of FDA MAUDE database
Zampini	Analysis of administrative database

References for excluded articles

Choe DH, Marom EM, Ahrar K, Truong MT, Madewell JE. Pulmonary embolism of polymethyl methacrylate during percutaneous vertebroplasty and kyphoplasty. *AJR Am J Roentgenol* 2004;183:1097-102.

Masala S, Lunardi P, Fiori R, et al. Vertebroplasty and kyphoplasty in the treatment of malignant vertebral fractures. *J Chemother* 2004;16 Suppl 5:30-3.

Mudano AS, Bian J, Cope JU, et al. Vertebroplasty and kyphoplasty are associated with an increased risk of secondary vertebral compression fractures: a population-based cohort study. *Osteoporos Int* 2009;20:819-26.

Muto M, Perrotta V, Guarnieri G, et al. Vertebroplasty and kyphoplasty: friends or foes? *Radiol Med* 2008;113:1171-84.

Nussbaum DA, Gailloud P, Murphy K. A review of complications associated with vertebroplasty and kyphoplasty as reported to the Food and Drug Administration medical device related web site. *J Vasc Interv Radiol* 2004;15:1185-92.

Zampini JM, White AP, McGuire KJ. Comparison of 5766 Vertebral Compression Fractures Treated With or Without Kyphoplasty. *Clin Orthop Relat Res* 2010.

APPENDIX D: LEVEL OF EVIDENCE DETERMINATION

Each study was rated against pre-set criteria that resulted in an evidence rating (Level of Evidence I, II, III, or IV) and presented in a table. For therapeutic and prognostic articles, the criteria are listed in the Table below.

Definition of the different levels of evidence for articles on therapy and prognosis

Level	Studies of Therapy		Studies of Prognosis	
	Study design	Criteria	Study design	Criteria
I	Good quality RCT	<ul style="list-style-type: none"> • Concealment • Blind or independent assessment for important outcomes • Co-interventions applied equally • F/U rate of 80%+ • Adequate sample size 	Good quality cohort	<ul style="list-style-type: none"> • Prospective design • Patients at similar point in the course of their disease or treatment • F/U rate of 80%+ • Patients followed long enough for outcomes to occur • Controlling for extraneous prognostic factors*
II	Moderate or poor quality RCT	<ul style="list-style-type: none"> • Violation of any of the criteria for good quality RCT 	Moderate quality cohort	<ul style="list-style-type: none"> • Prospective design, with violation of one of the other criteria for good quality cohort study • Retrospective design, meeting all the rest of the criteria in level I
	Good quality cohort	<ul style="list-style-type: none"> • Blind or independent assessment in a prospective study, or use of reliable data* in a retrospective study • Co-interventions applied equally • F/U rate of 80%+ • Adequate sample size • Controlling for possible confounding† 		
III	Moderate or poor quality cohort	<ul style="list-style-type: none"> • Violation of any of the criteria for good quality cohort 	Poor quality cohort	<ul style="list-style-type: none"> • Prospective design with violation of 2 or more criteria for good quality cohort, or • Retrospective design with violation of 1 or more criteria for good quality cohort
	Case-control	<ul style="list-style-type: none"> • Any case-control design 	Case-control	<ul style="list-style-type: none"> • Any case-control design
IV	Case series	<ul style="list-style-type: none"> • Any case series design 	Case series	<ul style="list-style-type: none"> • Any case series design

*Reliable data are data such as mortality or reoperation.

†Authors must provide a description of robust baseline characteristics, and control for those that are unequally distributed between treatment groups.

Methods for critical appraisal and level of evidence assessment

The method used for assessing the quality of evidence of individual studies as well as the overall quality of evidence incorporates aspects of rating scheme developed by the Oxford Centre for Evidence-based Medicine,¹ precepts outlined by the Grades of Recommendation Assessment, Development and Evaluation (GRADE) Working Group,² and recommendations made by the Agency for Healthcare Research and Quality (AHRQ).³ Taking into account features of methodological quality and important sources of bias combines epidemiologic principles with characteristics of study design.

Procedures for determining adherence to level of evidence (LoE) criteria

Each study was rated against pre-set criteria that resulted in an evidence rating (Level of Evidence I, II, III, or IV) and presented in a table. For therapeutic articles, the criteria are listed in the Table below and an example is given. All criteria met are marked. A blank for the criterion indicates that the criterion was not met, could not be determined or was not reported by the author.

Example of methods evaluation for articles on therapy

Methodological Principle	Author 1	Author 2	Author 3	Author 4
Study design				
Randomized controlled trial	√	√		
Cohort Study			√	
Case-series				√
Statement of concealed allocation*	√	√		
Intention to treat*	√	√		
Independent or blind assessment	√		√	
Co-interventions applied equally	√	√	√	
Complete follow-up of ≥85%	√			√
Adequate sample size	√	√	√	
Controlling for possible confounding	√	√	√	
Evidence Level	I	II	III	IV

* Applies to randomized controlled trials only.

Determination of overall strength of evidence

Following the assessment of the quality of each individual study included in the report, an overall “strength of evidence” for the relevant question or topic is determined. Methods for determining the overall strength of evidence for diagnostic studies are variable across the literature and are most applicable to evaluation of therapeutic studies.

SRI’s method incorporates the primary domains of quality (LoE), quantity of studies and consistency of results across studies as described by AHRQ.³

The following definitions are used by SRI to determine whether or not the body of evidence meets the criteria for each domain:

Domain	Definition/Criterion
Quality	<ul style="list-style-type: none"> At least 80% of the studies are LoE I or II
Quantity	<ul style="list-style-type: none"> There are at least three studies which are adequately powered to answer the study question
Consistency	<ul style="list-style-type: none"> Study results would lead to a similar conclusion (similar values, in the same direction) in at least 70% of the studies

Based on the criteria described above, the possible scenarios that would be encountered are described below. Each scenario is ranked according to the impact that future research is likely to have on both the overall estimates of an effect and the confidence in the estimate. This ranking describes the overall “Strength of Evidence” (SoE) for the body of literature on a specific topic. The method and descriptions of overall strength are adapted for diagnostic studies from system described by the GRADE Working Group² for the development of clinical guidelines.

SoE	Description	Further Research Impact	Domain Criterion Met		
			Quality	Quantity	Consistency
1	High	Very unlikely to change confidence in effect estimate	+	+	+
2	Moderate	Likely to have an important impact on confidence in estimate and <i>may</i> change the estimate	+	-	+
			+	+	-
3	Low	Very likely to have an important impact on confidence in estimate and <i>likely</i> to change the estimate	+	-	-
			-	+	+
4	Very Low	Any effect estimate is uncertain	-	+	-
			-	-	+
			-	-	-

Assessment of economic studies

Full formal economic analyses evaluate both costs and clinical outcomes of two or more alternative interventions. The four primary types are cost minimization analysis (CMA), cost-utility analysis (CUA), cost-effectiveness analysis (CEA), and cost-benefit analyses (CBA). Each employs different methodologies, potentially complicating critical appraisal, but some common criteria can be assessed across studies.

No standard, universally accepted method of critical appraisal of economic analyses is currently in use. A number of checklists [Canadian, BMJ, AMA] are available to facilitate critique of such studies. The Quality of Health Economic Studies (QHES) instrument developed by Ofman et al.⁴ QHES embodies the primary components relevant for critical appraisal of economic studies.^{4,5} It also incorporates a weighted scoring process and which was used as one factor to assess included economic studies. This tool has not yet undergone extensive evaluation for broader use but provides a valuable starting point for critique.

In addition to assessment of criteria in the QHES, other factors are important in critical appraisal of studies from an epidemiologic perspective to assist in evaluation of generalizability and potential sources of study bias.

Such factors include:

- Are the interventions applied to similar populations (e.g., with respect to age, gender, medical conditions, etc)? To what extent are the populations for each intervention comparable and are differences considered or accounted for? To what extent are population characteristics consistent with “real world” applications of the comparators?
- Are the sample sizes adequate so as to provide a reasonable representation of individuals to whom the technology would be applied?
- What types of studies form the basis for the data used in the analyses? Data (e.g., complication rates) from randomized controlled trials or well-conducted, methodologically rigorous cohort studies for data collection are generally of highest quality compared with case series or studies with historical cohorts.
- Were the interventions applied in a comparable manner (e.g., similar protocols, follow-up procedures, evaluation of outcomes, etc)?
- How were the data and/or patients selected or sampled (e.g., a random selection of claims for the intervention from a given year/source or all claims)? What specific inclusion/exclusion criteria or processes were used?
- Were the outcomes and consequences of the interventions being compared comparable for each? (e.g., were all of the relevant consequences/complications for each intervention considered or do they primarily reflect those for one intervention?)

Assessment of the overall strength of evidence for formal economic analyses does not appear to be documented in the literature. For the purposes of this HTA, overall strength was determined by:

- Quality of the individual studies: Where the majority of quality indicators described in the QHES met and were the methods related to patient/claim selection, patient population considerations and other factors listed above consistent with a high quality design?
- Number of formal analyses (3 or more)
- Consistency of findings and conclusions from analyses across studies.

QHEs Instrument ⁴	Study	Points	Yes	No
1. Was the study objective presented in a clear, specific, and measurable manner?		7		
2. Were the perspective of the analysis (societal, third-party payer, etc.) and reasons for its selection stated?		4		
3. Were variable estimates used in the analysis from the best available source (i.e., randomized controlled trial - best, expert opinion - worst)?		8		
4. If estimates came from a subgroup analysis, were the groups prespecified at the beginning of the study?		1		
5. Was uncertainty handled by (1) statistical analysis to address random events, (2) sensitivity analysis to cover a range of assumptions?		9		
6. Was incremental analysis performed between alternatives for resources and costs?		6		
7. Was the methodology for data abstraction (including the value of health states and other benefits) stated?		5		
8. Did the analytic horizon allow time for all relevant and important outcomes? Were benefits and costs that went beyond 1 year discounted (3% to 5%) and justification given for the discount rate?		7		
9. Was the measurement of costs appropriate and the methodology for the estimation of quantities and unit costs clearly described?		8		
10. Were the primary outcome measure(s) for the economic evaluation clearly stated and did they include the major short-term, long-term and negative outcomes included?		6		
11. Were the health outcomes measures/scales valid and reliable? If previously tested valid and reliable measures were not available, was justification given for the measures/scales used?		7		
12. Were the economic model (including structure), study methods and analysis, and the components of the numerator and denominator displayed in a clear, transparent manner?		8		
13. Were the choice of economic model, main assumptions, and limitations of the study stated and justified?		7		
14. Did the author(s) explicitly discuss direction and magnitude of potential biases?		6		
15. Were the conclusions/recommendations of the study justified and based on the study results?		8		
16. Was there a statement disclosing the source of funding for the study?		3		
TOTAL POINTS		100		

1. Oxford Centre for Evidence-based Medicine Levels of Evidence. 2009. (Accessed 9/27/10, at <http://www.cebm.net/?o=1025>.)
2. Atkins D, Best D, Briss PA, et al. Grading quality of evidence and strength of recommendations. *BMJ* 2004;328:1490.
3. West S, King V, Carey TS, et al. Systems to Rate the Strength Of Scientific Evidence. Rockville, MD: Agency for Healthcare Research and Quality; 2002.
4. Ofman JJ, Sullivan SD, Neumann PJ, et al. Examining the value and quality of health economic analyses: implications of utilizing the QHEs. *J Manag Care Pharm* 2003;9:53-61.
5. Chiou CF, Hay JW, Wallace JF, et al. Development and validation of a grading system for the quality of cost-effectiveness studies. *Med Care* 2003;41:32-44.

APPENDIX E: LEVEL OF EVIDENCE FOR COMPARATIVE STUDIES

Vertebroplasty versus sham surgery

Randomized controlled trials

Methodological quality of RCTs comparing PV with sham surgery

Methodological Principle	Buchbinder	Kallmes
Study design		
Randomized controlled trial	√	√
Cohort Study		
Case-series		
Statement of concealed allocation	√	√
Intention to treat	√	√
Independent or blind assessment	√	√
Co-interventions applied equally		
Complete follow-up of ≥85%	√	√
Adequate sample size	√	√
Controlling for possible confounding	√	√
Evidence Level	II	II

Vertebroplasty versus conservative medical treatment

Randomized controlled trials

Methodological quality of RCTs comparing PV with conservative medical treatment

Methodological Principle	Klazen	Rousing	Voormolen
Study design			
Randomized controlled trial	√	√	√
Cohort Study			
Case-series			
Statement of concealed allocation	√		√
Intention to treat	√		√
Independent or blind assessment			
Co-interventions applied equally	√		
Complete follow-up of ≥85%		√	
Adequate sample size	√		
Controlling for possible confounding	√		√
Evidence Level	II	II	II

Prospective cohort studies

Methodological quality of prospective cohort studies comparing PV with conservative medical treatment

Methodological Principle	Alvarez	Diamond
Study design Randomized controlled trial Cohort Study Case-series	√	√
Independent or blind assessment		
Co-interventions applied equally		√
Complete follow-up of $\geq 85\%$	√	
Adequate sample size		
Controlling for possible confounding		√
Evidence Level	III	III

Retrospective cohort studies

Methodological quality of retrospective cohort studies comparing PV with conservative medical treatment

Methodological Principle	Ehteshami Rad	Masala	Nakano
Study design Randomized controlled trial Cohort Study Case-series	√	√	√
Independent or blind assessment			
Co-interventions applied equally			√
Complete follow-up of $\geq 85\%$		√	
Adequate sample size			
Controlling for possible confounding			√
Evidence Level	III	III	III

Kyphoplasty compared with conservative medical treatment or other surgery

Randomized controlled trials

Methodological quality of RCT comparing KP with conservative medical treatment

Methodological Principle	Wardlaw
Study design Randomized controlled trial Cohort Study Case-series	√
Statement of concealed allocation	√
Intention to treat	√
Independent or blind assessment	
Co-interventions applied equally	
Complete follow-up of $\geq 85\%$	
Adequate sample size	√
Controlling for possible confounding	√
Evidence Level	II

Prospective cohort studies

Methodological quality of prospective cohort studies comparing KP with conservative medical treatment

Methodological Principle	Kasperk
Study design Randomized controlled trial Cohort Study Case-series	√
Independent or blind assessment	
Co-interventions applied equally	
Complete follow-up of $\geq 85\%$	
Adequate sample size	
Controlling for possible confounding	√
Evidence Level	III

Retrospective cohort studies

Methodological quality of retrospective cohort studies comparing KP with conservative medical treatment

Methodological Principle	An
Study design Randomized controlled trial Cohort Study Case-series	√
Independent or blind assessment	
Co-interventions applied equally	
Complete follow-up of $\geq 85\%$	
Adequate sample size	
Controlling for possible confounding	√
Evidence Level	III

Methodological quality of retrospective cohort studies comparing KP with posterior instrumentation

Methodological Principle	An	Ming
Study design Randomized controlled trial Cohort Study Case-series	√	√
Independent or blind assessment		
Co-interventions applied equally		
Complete follow-up of $\geq 85\%$		
Adequate sample size		
Controlling for possible confounding	√	√
Evidence Level	III	III

Vertebroplasty compared with kyphoplasty

Randomized controlled trials

Methodological quality of RCT comparing PV with KP

Methodological Principle	Liu
Study design Randomized controlled trial Cohort Study Case-series	√
Statement of concealed allocation	
Intention to treat	
Independent or blind assessment	
Co-interventions applied equally	√
Complete follow-up of $\geq 85\%$	
Adequate sample size	
Controlling for possible confounding	√
Evidence Level	II

Prospective cohort studies

Methodological quality of prospective cohort studies comparing PV with KP

Methodological Principle	De Negri	Grohs	Lovi	Röllinghoff	Santiago	Schofer
Study design Randomized controlled trial Cohort Study Case-series	√	√	√	√	√	√
Independent or blind assessment		√				
Co-interventions applied equally						√
Complete follow-up of $\geq 85\%$			√	√		√
Adequate sample size						
Controlling for possible confounding		√				√
Evidence Level	III	III	III	III	III	III

Retrospective cohort studies

Methodological quality of retrospective cohort studies comparing PV with KP

Methodological Principle	Four-ney	Frankel	Hiwa-tashi	Köse	Lee	Zhou
Study design Randomized controlled trial Cohort Study Case-series	√	√	√	√	√	√
Independent or blind assessment						
Co-interventions applied equally						
Complete follow-up of $\geq 85\%$			√	√		
Adequate sample size						
Controlling for possible confounding		√	√			√
Evidence Level	III	III	III	III	III	III

APPENDIX F: DATA TABLES: Demographic and study characteristics for comparative studies

Table 1: Characteristics of RCTs comparing percutaneous vertebroplasty with other treatments.

Author (year)	Study design (LoE)	Study period	Demographics	Follow-up (% followed)	Characteristics	Interventions	Outcomes	Funding
Vertebroplasty versus Sham								
Buchbinder (2009)	RCT Multicenter (4, Australia)	April 2004 to October 2008	<p><u>PVP</u> n = 38 female: 82% age: 74.2 years (\pm 14) BMI: 25.6 kg/m² (\pm 5.5)</p> <p><u>Sham</u> n = 40 female: 78% age: 78.9 years (\pm 9.5) BMI: 24.6 kg/m² (\pm 5.7)</p>	6 months (91%, n = 71/78)	<ul style="list-style-type: none"> • Fracture type: osteoporotic • Fracture age: \leq 1 year old (based on duration of pain) • Duration of back pain (median): <i>PVP</i>: 9.0 weeks <i>Sham</i>: 9.5 weeks • Duration of symptoms < 6 weeks: <i>PVP</i>: 32% (n = 12) <i>Sham</i>: 32% (n = 13) • Severity of fracture: <i>PVP</i>: mild, 29% (13/45); moderate, 47% (21/45); severe, 24% (11/45) <i>Sham</i>: mild, 26% (12/47); moderate, 51% (24/47); severe, 23% (11/47) • Number of vertebral bodies treated: <i>PVP</i>: one, 82% (n = 31); two, 18% (n = 7) <i>Sham</i>: one, 82% (n = 33); two, 18% (n = 7) • One or more previous vertebral fractures: <i>PVP</i>: 47% (n = 18) <i>Sham</i>: 52% (n = 21) • Fracture appearance <i>PVP</i>: biconcave, 9% (n = 4); crush, 13% (n = 6); wedge, 70% 	<ul style="list-style-type: none"> • PVP under conscious sedation using PMMA (approximately 3 ml); continuous fluoroscopy; cephalothin • Sham procedure • After both procedures patients received “usual care”; analgesia was given according to standard practice 	<p><u>Primary</u></p> <ul style="list-style-type: none"> • Overall pain score <p><u>Secondary</u></p> <ul style="list-style-type: none"> • Quality of life (QUALEFFO, AQoL, EQ-5D) • Pain at rest and at night • Modified RDQ • Perceived recovery • Adverse events 	<p>Supported by grants from the National Health and Medical Research Council of Australia, Arthritis Australia, the Carbini Education and Research Institute, and Cook Australia</p> <p>Dr. Buchbinder reports receiving grant support from Cook Australia to perform this trial; no other potential conflict of interest was reported</p>

					(n = 33) <i>Sham</i> : biconcave, 9% (n = 4); crush, 21% (n = 10); wedge, 78% (n = 35) • Crossover interventions NR			
Kallmes (2009)	RCT Multicenter (5 United States, 5 United Kingdom, 1 Australia)	NR	<u>PVP</u> n = 68 female: 78% age: 73.4 years (± 9.4) BMI: NR <u>Sham</u> n = 63 female: 73% age: 74.3 years (± 9.6) BMI: NR	1 month (98%, n = 128/131) 3 months (95%, n = 125/131)	<ul style="list-style-type: none"> Fracture type: osteoporotic Fracture age: ≤ 1 year old (base on duration of pain) Pain duration (mean): <i>PVP</i>: 16 weeks <i>Sham</i>: 20 weeks Number of levels treated: <i>PVP</i>: one, 71% (48); two, 19% (13); three, 10% (7) <i>Sham</i>: one, 65% (n = 41); two, 22% (n = 14); three, 13% (8) Fracture severity NR Cross-over to other intervention allowed after 1 month or later if adequate pain relief not achieved <i>PVP</i>: 1 at < 1 month and 8 at < 3 months <i>Sham</i>: 2 at < 1 month and 27 at < 3 months 	<ul style="list-style-type: none"> PVP using PMMA under fluoroscopy Sham procedure 	<u>Primary</u> • Modified RDQ <u>Secondary</u> • Pain Frequency Index • Pain Bothersomeness Index • SOF-ADL scale • EQ-5D • SF-36	<p>No commercial entity paid for any materials used in the study.</p> <p>Research funds paid for all costs related to the control interventions</p> <p>Costs of the vertebroplasty procedure were billed to insurance</p>
Vertebroplasty versus Conservative Treatment								
Klazen, Lohle (2010)*/ Klazen, Venmans (2010)*/	RCT VERTOS II Multicenter (5 Netherlands, 1 Belgium)	October 2005 to June 2008	<u>PVP</u> n = 101 female: 69% age: 75.2 (± 9.8) years BMI: NR <u>Conservative</u> n = 101 female: 69% age: 75.4 (± 8.4) years BMI: NR	1 year (87%, n = 176/202)	<ul style="list-style-type: none"> Fracture type: osteoporotic Fracture age (≤ 6 weeks based on duration of back pain): <i>PVP</i>: 29.3 (± 17.1) days <i>Conservative</i>: 26.8 (± 16.0) days Number of fractures at baseline (mean per patient) <i>PVP</i>: 2.4 ± 1.9 (1–5) <i>Conservative</i>: 2.1 ± 1.5 (1–5) Fracture severity (with bone edema) <i>PVP</i> (n = 136): mild, 42% (n = 57); moderate, 43% (n = 58); severe, 15% (n = 21) <i>Conservative</i>(n = 120): mild, 	<ul style="list-style-type: none"> PVP using PMMA under continuous fluoroscopy, with osteoporosis medication and analgesics if necessary Conservative treatment consisting of analgesics, bisphosphonates, calcium supplements, and vitamin D 	<u>Klazen, Lohle (2010)</u> • Pain relief at 1 month and 1 year (primary) • Cost-effectiveness (secondary) <u>Klazen, Venmans (2010)</u> • Incidence, distribution and timing of new vertebral	<p>This study was sponsored by ZonMw (The Netherlands Organization for Health Research and Development and an unrestricted grant from Cook Medical, Bloomington, IN, USA.</p>

					<p>46% (n = 55); moderate, 38% (n = 45); severe, 17% (n = 20)</p> <ul style="list-style-type: none"> • Fracture shape <i>PVP</i>: wedge, 66% (n = 90/136); biconcave, 34% (n = 46/136) <i>Conservative</i>: wedge, 81% (n = 97/120); biconcave, 19% (n = 23/120) • Vertebral level with bone edema <i>PVP</i>: T5-T10 (n = 19); T11-L2 (n = 91); L3-L5 (n = 29) <i>Conservative</i>: T5-T10 (n = 32); T11-L2 (n = 66); L3-L5 (n = 28) • Crossover interventions NR 		compression fractures	The sponsors of this study had no role in study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit the paper for publication
Venmans, Klazen, van Rooij (2010)†/ Venmans, Klazen, Lohle (2010)†	RCT VERTOS II Multicenter (5 Netherlands, 1 Belgium)	October 2005 to June 2008	<u>PVP</u> n = 54 female: 67% age: 74 years (53–88) BMI: NR <u>Conservative</u> : NR	2 years (range, 6–42 months) Patients in PVP group with follow-up CT (55%, 54/98)	<ul style="list-style-type: none"> • Fracture type: osteoporotic • Fracture age (≤ 6 weeks based on duration of back pain): <i>PVP</i>: 29.3 (± 17.1) days <i>Conservative</i>: 26.8 (± 16.0) days • Number of fractures at baseline (mean per patient) <i>PVP</i>: 2.4 \pm 1.9 (1–5) <i>Conservative</i>: 2.1 \pm 1.5 (1–5) • Fracture severity (with bone edema) <i>PVP</i> (n = 136): mild, 42% (n = 57); moderate, 43% (n = 58); severe, 15% (n = 21) <i>Conservative</i> (n = 120): mild, 46% (n = 55); moderate, 38% (n = 45); severe, 17% (n = 20) • Fracture classification <i>PVP</i>: wedge, 66% (n = 90/136); biconcave, 34% (n = 46/136) <i>Conservative</i>: wedge, 81% (n = 97/120); biconcave, 19% (n = 23/120) 	<ul style="list-style-type: none"> • PVP using PMMA under continuous fluoroscopy, with osteoporosis medication and analgesics if necessary • Conservative treatment consisting of analgesics, bisphosphonates, calcium supplements, and vitamin D 	<p><u>Venmans, Klazen, van Rooij (2010)</u></p> <ul style="list-style-type: none"> • Perivertebral venous, discal, and soft-tissue cement leakage on postprocedural and follow-up CT scans <p><u>Venmans, Klazen, Lohle (2010)</u></p> <ul style="list-style-type: none"> • Incidence of pulmonary cement embolism 	<p>No conflicts of interest declared</p> <p>This study was sponsored by ZonMw (The Netherlands Organization for Health Research and Development and an unrestricted grant from Cook Medical, Bloomington, IN, USA.</p> <p>The sponsors of this study had no role in study design, data collection, data analysis, data interpretation,</p>

					<ul style="list-style-type: none"> • Vertebral level with bone edema <i>PVP</i>: T5-T10 (n = 19); T11-L2 (n = 91); L3-L5 (n = 29) <i>Conservative</i>: T5-T10 (n = 32); T11-L2 (n = 66); L3-L5 (n = 28) Crossover interventions NR 			<p>writing of the report, or the decision to submit the paper for publication</p> <p>No conflicts of interest declared</p>
Rousing (2010, 2009)†	RCT One center (Denmark)	January 2001 to January 2008	<p><u>PVP</u> n = 25 female: 76% age: 80 years (65–96) BMI: NR</p> <p><u>Conservative</u> n = 24 female: 88% age: 80 years (71–93) BMI: NR</p>	<p>3 months (95%, 47/49)</p> <p>1 year (92%, 45/49)</p>	<ul style="list-style-type: none"> • Fracture type: osteoporotic • Fracture age (acute, < 2 weeks; or subacute, 2–8 weeks): <i>PVP</i>: 8.4 days <i>Conservative</i>: 6.7 days • Fracture location: <i>PVP</i>: D7-D11, 2; D12, 3; L1, 13; L2, 4; L3, 5; L4, 4; L5, 0 <i>Conservative</i>: D7-D11, 3; D12, 4; L1, 12; L2, 6; L3, 4; L4, 3; L5, 0 • Number of fractures treated <i>PVP</i>: one, n = 19; two, n = 6; three, n = 0 <i>Conservative</i>: one, n = 18; two, n = 4; three, n = 2 • Fracture severity NR • Crossover interventions NR 	<ul style="list-style-type: none"> • PVP using PMMA under continuous fluoroscopy and mild, conscious sedation; pain medication; physiotherapy • Conservative treatment consisting of hospitalization, pain medication, physiotherapy, and brace treatment. 	<p><u>Primary</u></p> <ul style="list-style-type: none"> • SF-36 • DPQ • VAS for pain (0–10) <p>After a PhD-study was affiliated to project in November 2004:</p> <ul style="list-style-type: none"> • EQ5D • Barthel Index • Modified MMSE • 3 physical tests 	<p>Foundation and Danish government funds were received in support of this work.</p> <p>No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this report.</p>
Voormolen (2007)	RCT VERTOS Multicenter (3, Netherlands, Belgium)	July 2003 to June 2005	<p><u>Total</u> N = 34 female: 82% age: 73 years (55–88) BMI: NR</p> <p><u>PVP</u> n = 18 female: 78% age: 72 years (59–84) BMI: NR</p>	<p>2 weeks (100%)</p>	<ul style="list-style-type: none"> • Fracture type: osteoporotic only • Fracture age (based on duration of back pain): <i>PVP</i>: 85 days <i>Conservative</i>: 76 days • Total number of treated fractures <i>PVP</i>: 28 <i>Conservative</i>: 21 • Mean fractures per patient <i>PVP</i>: 1.6 (1–3) <i>Conservative</i>: 1.2 (1–2) • Severity of fractures: 	<ul style="list-style-type: none"> • PVP using PMMA under continuous fluoroscopy • Conservative treatment consisting of OPM (paracetamol, NSAIDs, or opiate derivatives) 	<ul style="list-style-type: none"> • VAS for pain (0–10) • Analgesic use • QUALEFFO • RMD 	<ul style="list-style-type: none"> • NR

			<p><u>Conservative</u> n = 16 female: 88% age: 74 years (55–88) BMI: NR</p>		<p><i>PVP</i>: mild, 11% (3/28); moderate, 21% (6/28); severe, 68% (19/28) <i>Conservative</i>: mild, 14% (3/21); moderate, 24% (5/21); severe, 62% (13/21)</p> <ul style="list-style-type: none"> • Shape of fracture <i>PVP</i>: wedge, 89% (n = 25); biconcave, 11% (n = 3) <i>Conservative</i>: wedge, 62% (n = 13); biconcave, 38% (n = 8) • Compression of treated fractures <i>PVP</i>: 47% (23%–72%) <i>Conservative</i>: 42% (15%–68%) • Distribution of treated fractures: T6-L5 • Crossover interventions: All patients in the OPM arm requested to be treated by PVP 2 weeks after start of therapy; thus follow-up after 2 weeks was not analyzed 		
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AQoL: Assessment of Quality of Life questionnaire; DPQ: Dallas Pain Questionnaire; EQ-5D: European Quality of Life-5 Dimensions scale; MMSE: mini-mental state exam; NR = not reported; NSAIDs: non-steroidal anti-inflammatory drugs; OPM: optimal pain medication; PMMA: polymethylmethacrylate; QUALEFFO: Quality of Life Questionnaire of the European Foundation for Osteoporosis; RDQ: Roland-Morris Disability Questionnaire; SF-36: Medical Outcomes Short Form-36 questionnaire; SOF-ADL: Study of Osteoporotic Fractures-Activities of Daily Living; VAS: visual analog scale.

*Both Klazen 2010 studies reported on the same population of patients from the VERTOS II study, comparing PVP with conservative treatment, but reported different outcome measures.

†Both studies by Venmans 2010 used results from the PVP group (n = 98) of the VERTOS II study (PVP vs. conservative treatment) to analyze 1) perivertebral cement leakage and 2) pulmonary cement embolism. Thus, demographics and results for both studies were reported only for the 54 PVP patients who had follow-up CT scans at a mean 22 months.

‡Initial study (2009) reported outcomes at 3 months. Outcomes at 1 year were reported in a subsequent publication in 2010.

Table 2: Characteristics of RCTs comparing kyphoplasty with other treatments.

Author (year)	Study design (LoE)	Study period	Demographics	Follow-up (% followed)	Characteristics	Interventions	Outcomes	Funding
Kyphoplasty versus Conservative								
Wardlaw (2009)	RCT FREE study Multicenter (21 sites, 8 countries)	February 2003 to December 2005	<p><u>KP</u> n = 149 female: 77% age: 72.2 years (± 9.3) BMI: NR</p> <p><u>Conservative</u> n = 151 female: 77% age: 74.1 years (± 9.4) BMI: NR</p>	<p>1 month (87%, n = 266/300)</p> <p>3 months (84%, n = 251/300)</p> <p>6 months (82%, n = 246/300)</p> <p>1 year (78%, n = 235/300)</p>	<ul style="list-style-type: none"> Underlying cause: <ul style="list-style-type: none"> <i>Primary osteoporosis</i> KP: 97% (n = 145) Conservative: 95% (n = 143) <i>Secondary osteoporosis</i> KP: 1% (n = 2) Conservative: 4% (n = 6) <i>Multiple myeloma/metastatic</i> KP: 1% (n = 2) Conservative: 1% (n = 2) Fracture age: <i>KP</i>: 5.6 (±4.4) weeks <i>Conservative</i>: 6.4 (±5.2) weeks Fracture severity (Genant assessment): <i>Grade 2 (25%–40% deformity)</i> KP: 18.9% (n = 64/338) Conservative: 21.6% (n = 73/338) <i>Grade 3 (> 40% deformity)</i> KP: 14.5% (n = 49/338) Conservative: 14.8% (n = 50/338) Fracture location <i>T5-T9</i> KP: 23% (n = 49) Conservative: 21% (n = 41) <i>T10-L2</i> KP: 59% (n = 127) Conservative: 67% (n = 130) <i>L3-L5</i> KP: 15% (n = 38) Conservative: 12% (n = 24) Number of fractures <i>KP</i>: one, 67% (n = 100); two, 	<ul style="list-style-type: none"> KP using PMMA by percutaneous, transpedicular, or extrapedicular approach; most procedures done under general anesthesia; same care as conservative group Conservative treatment consisting of analgesics, bed rest, back braces, physiotherapy, rehabilitation programs, and walking aids 	<p><u>Primary</u></p> <ul style="list-style-type: none"> Differences in changes from baseline to 1 month in the SF-36 PCS scale <p><u>Secondary</u></p> <ul style="list-style-type: none"> SF-36 subscales EQ-5D RMD scale Self-rated back pain Analgesic use Restricted activity days and bed rest due to back pain Adverse events 	Medtronic Spine LLC contributed to study design, data monitoring, and reporting of results, and paid for statistical analysis. An independent statistician received the entire data set and verified the statistical analyses and the primary endpoint data by comparing a 10% random sample with case report forms. The publication committee, which did not include the sponsor, approved the final version and had final responsibility for the decision to submit for publication.

					<p>23% (n = 34); three, 10% (n = 15) <i>Conservative:</i> one, 76% (n = 115); two, 19% (n = 28); three, 5% (n = 8)</p> <ul style="list-style-type: none"> • Crossover interventions NR; however in the conservative group, 15 patients withdrew and underwent unspecified surgeries 			
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EQ-5D: European Quality of Life-5 Dimensions scale; KP: Kyphoplasty; NR = not reported; PMMA: polymethylmethacrylate; RDQ: Roland-Morris Disability Questionnaire; SF-36: Medical Outcomes Short Form-36 questionnaire; PCS: Physical Component Score of the SF-36.

Table 3: Characteristics of RCTs comparing percutaneous vertebroplasty with balloon kyphoplasty.

Author (year)	Study design (LoE)	Study period	Demographics	Follow-up (% followed)	Characteristics	Interventions	Outcomes	Funding
Vertebroplasty versus Kyphoplasty								
Liu (2010)	RCT	NR	<p><u>KP</u> n = 50 female: 78% age: 72.3 (± 7.6) years (57–88) BMI: NR</p> <p><u>PVP</u> n = 50 female: 76% age: 74.3 (± 6.4) years (57–84) BMI: NR</p>	6 months (%NR)	<ul style="list-style-type: none"> • Fracture type: osteoporotic; thoraco-lumbar junction • Fracture distribution: <i>T12</i>: KP, 38% (n = 19); PVP, 38% (n = 19) <i>L1</i>: KP, 62% (n = 31); PVP, 62% (n = 31) • Duration between injury and surgery KP, 17.0 (± 7.7) days PVP, 15.8 (± 6.7) days • Amount of PMMA: KP, 5.56 ± 0.62 PVP, 4.91 ± 0.65 • Fracture severity NR • Crossover interventions NR 	<ul style="list-style-type: none"> • Balloon kyphoplasty and percutaneous vertebroplasty under IV general anesthesia; both procedures used PMMA and were performed under a mobile C-arm x-ray 	<ul style="list-style-type: none"> • VAS pain score • Vertebral body height • Kyphotic wedge angle 	This study was supported by the grant from Chung-Shan Medical University Hospital.

KP: balloon kyphoplasty; NR: not reported; PMMA: polymethylmethacrylate; PVP: percutaneous vertebroplasty; VAS: visual analog scale.

Table 4: Characteristics of nonrandomized studies comparing percutaneous vertebroplasty with other treatments.

Author (year)	Study design (LoE)	Study period	Demographics	Follow-up (% followed)	Characteristics	Interventions	Outcomes
Vertebroplasty versus Conservative							
Diamond (2006)	Prospective Cohort	November 2000 to December 2002	<p><u>PVP</u> n = 88 female: 64% age: 76.8 years (\pm 8.7) BMI: NR</p> <p><u>Conservative</u> n = 38 female: 82% age: 76.1 years (\pm 10.0) BMI: NR</p>	<p>2 years (94%; n = 119/126)</p> <p>PVP: 93% (n = 82/88)</p> <p>Conservative: 97% (n = 37/38)</p>	<ul style="list-style-type: none"> Fracture type: osteoporotic Fracture age: acute, occurring within 1-6 weeks (based on duration of pain) Severity of fracture: NR Number of vertebral bodies treated: NR One or more previous vertebral fractures: PVP 3.5 \pm 1.8 Conservative 3.1 \pm 1.6 Smokers PVP: n = 11 (13%) Conservative: n = 4 (11%) Alcohol excess PVP: n = 15 (17%) Conservative: n = 6 (16%) Corticosteroid therapy PVP: n = 25 (28%) Conservative: n = 9 (24%) Crossover: NR 	<ul style="list-style-type: none"> PVP Conservative treatment (those who declined to undergo PVP) All patients were offered similar analgesia. All patients received anti-osteoporotic medication. 70 mg oral alendronate weekly (n = 57) or 60 mg intravenous pamidronate 6 times per month (n = 69). All patients received 1200 mg of elemental calcium and 0.25μg ergocalciferol daily (if vitamin D deficient) 	<ul style="list-style-type: none"> Fracture-related complications Level of function using Barthel index VAS pain score Total number of hospital beds Mortality/causes of death Vertebral morphology New (incident) vertebral fractures New clinical event (recurrent back pain occurring more than 6 weeks after initial presentation)
Alvarez (2006)	Prospective Cohort	NR	<p><u>PVP</u> n = 101 female: 80% age: 73.3 \pm 7.9 years BMI: NR</p> <p><u>Conservative</u> n = 27 female: 80% age: 69.7 \pm 7.7 years BMI: NR</p>	1 year (100%)	<ul style="list-style-type: none"> Fracture type: osteoporotic; poor response to conventional treatment Fracture age (mean): PVP: 5 \pm 3.7 years Conservative: 5.8 \pm 3.7 years Number of vertebrae treated per patient: PVP: 1.5 \pm 0.6 Conservative: 1.03 \pm 0.1 Location of fractured vertebrae (mean): <u>PVP</u> Thoracic: n = 30 (19.7%) Thoracolumbar: n = 77 (50.6%) Lumbar: n = 45 (29.6%) <u>Conservative</u> Thoracic: n = 5 (17.8%) Thoracolumbar: n = 15 (53.5%) Lumbar: n = 8 (28.5%) 	<ul style="list-style-type: none"> PVP using PMMA before February 2002 after February 2002 the PMMA used included barium sulfate Conservative treatment (those who declined to undergo PVP) Conservative therapy included bed rest, orally administered pain medication, and bracing. Both groups were received analgesia in 4 staged groups: major opiates, minor opiates, nonsteroidal anti- 	<ul style="list-style-type: none"> VAS pain score Decrease in analgesic dosage SF-36 health survey performed to assess the clinical outcome of both groups. Owestry functional test Patients were asked about satisfaction at 1 year follow-up

					<ul style="list-style-type: none"> Height Loss (mean) <ul style="list-style-type: none"> <u>PVP</u>: <ul style="list-style-type: none"> < 30%: n = 41 (26.9%) 30%–50%: n = 71 (46.7%) 50%–70%: n = 40 (26.3%) <u>Conservative</u>: <ul style="list-style-type: none"> < 30%: n = 10 (35%) 30%–50%: n = 10 (35%) 50%–70%: n = 8 (30%) Crossover: NR 	inflammatory agents, and no analgesia	
Nakano (2006)	Retrospective Cohort	August 2000 to April 2002	<p><u>PVP</u> n = 30 female: 73% age: 77 ± 7 years BMI: NR</p> <p><u>Conservative</u> n = 30 female: 73% age: 77 ± 8.2 years BMI: NR</p>	1.4 years (%NR)	<ul style="list-style-type: none"> Fracture type: osteoporotic; symptomatic Fractures were classified into 2 grades based on the existence of posterior wall defects of the vertebral body: <ul style="list-style-type: none"> Grade 1, no fracture of the posterior wall <ul style="list-style-type: none"> PVP: n = 16 Conservative: n = 16 Grade 2, posterior wall fracture with displacement of less than 2mm <ul style="list-style-type: none"> PVP: n = 14 Conservative: n = 14 Fracture distribution <ul style="list-style-type: none"> Thoracic <ul style="list-style-type: none"> PVP, n = 5 (17%) Conservative, n = 5 (17%) Thoracolumbar <ul style="list-style-type: none"> PVP, n = 20 (67%) Conservative, n = 20(67%) Lumbar <ul style="list-style-type: none"> PVP, n = 5 (17%) Conservative, n = 5 (17%) Fracture age: < 4 weeks Crossover: NR 	<ul style="list-style-type: none"> PVP using PMMA under continuous fluoroscopic guidance All patients in both groups were offered similar analgesic medication All patients were offered physical exercise regimens including; muscle exercise of the extremities while in a cast for 8 weeks and a thoracolumbralsacral orthosis for an additional 6 weeks. 	<ul style="list-style-type: none"> VAS pain scale (back and low back) Duration of analgesic requirements Deformity of VB Kyphotic deformity of VB
Masala (2008)	Retrospective Cohort	September 2004 to September 2005	<p><u>PVP</u> n = 58 female: 72% age: 73.5 ± 8.9 years BMI: NR</p>	1 year (91%; 140/153) PVP: 93% (n = 54/58)	<ul style="list-style-type: none"> Fracture type: acute, osteoporotic, amyelic, symptomatic vertebral fractures Fracture age: acute; ≤ 3 months Crossover: NR 	<ul style="list-style-type: none"> All patients underwent 2 weeks of analgesic drug therapy, those still with refractory pain were offered PVP PVP: same analgesic 	<ul style="list-style-type: none"> Cost-effectiveness of PVT compared to CMT VAS pain scale ADL scale for level of function

			<p><u>Conservative:</u> n = 95 female: 74% age: 70.2 ± 7.68 BMI: NR</p>	<p>Conservative: 91%; (n = 86/95)</p>		<p>regimen as conservative</p> <ul style="list-style-type: none"> Conservative Patients continued the preexisting analgesic drug therapy for 3 weeks. After this period oral administration of 5-15mg x 2/day of oxycodone, 50-200mg x 2/day of tramadol, and 300-800mg x 3/day of gabapentin. All patients both PVP and conservative received an orthopedic back brace All patients also underwent physical therapy. 	
Ehteshami (2010)	Retrospective cohort	April 2004 to September 2006	<p><u>PVP (Group 1):</u> n = 269 female: 70% median age: 77 years (35–97) BMI: NR</p> <p><u>Conservative (Group 2):</u> n = 107 female: 60% median age: 74 years (22–91) BMI: NR</p> <p><u>Conservative (Group 2a)</u> n = 82 female: 59% median age: 75 years (22–91) BMI: NR</p>	<p>Group 1 = 10 months Group 2 = 18 months Group 3 = 18.5 months</p>	<ul style="list-style-type: none"> Fracture type: NR Fracture age: NR Crossover: NR Time to incident fractures: Group 1: 5.5 ± 4.2 months (0.25–12) Group 2: 10 ± 10.6 months (0.5–28) Group 2a: 9 ± 11.1 months (0.5–28) Chronic fractures: Group 1: 39% Group 2: 67% Group 2a: 57% Incident fractures: Group 1: n = 39 (14%) Group 2: n = 8 (7%) Group 2a: n = 7 (9%) 	<ul style="list-style-type: none"> Underwent PVP (Group 1) within 7 days of initial evaluation Conservative treatment (Group 2) Conservative treatment in patients from group 2 after exclusion of patients with exclusively chronic fractures (Group 2a) 	<ul style="list-style-type: none"> Incident fractures

AQoL: Assessment of Quality of Life questionnaire; DPQ: Dallas Pain Questionnaire; EQ-5D: European Quality of Life-5 Dimensions scale; MMSE: mini-mental state exam; NR = not reported; NSAIDs: non-steroidal anti-inflammatory drugs; OPM: optimal pain medication; PMMA: polymethylmethacrylate; QUALEFFO: Quality of Life Questionnaire of the European

Foundation for Osteoporosis; RDQ: Roland-Morris Disability Questionnaire; SF-36: Medical Outcomes Short Form-36 questionnaire; SOF-ADL: Study of Osteoporotic Fractures-Activities of Daily Living; VAS: visual analog scale.

*Initial study (2009) reported outcomes at 3 months. Outcomes at 1 year were reported in a subsequent publication in 2010.

†Venmans 2010 used results from the PVP group (n = 98) of the VERTOS II study (PVP vs. conservative treatment) to analyze perivertebral cement leakage. Thus, demographics and results were reported only for the 54 patients who had follow-up CT scans at a mean 22 months.

Table 5: Characteristics of nonrandomized studies comparing kyphoplasty with other treatments.

Author (year)	Study design (LoE)	Study period	Demographics	Follow-up (% followed)	Characteristics	Interventions	Outcomes
Kyphoplasty versus Conservative							
Kasperk (2005)	Prospective cohort	May 2002 to September 2002	<p><u>KP</u> n = 40 female: 85% mean age: 68.7 years BMI: NR</p> <p><u>Conservative</u> n = 20 female: 75% mean age: 70.1 years BMI: NR</p>	<p>1 month (87%, n = 266/300)</p> <p>3 months (84%, n = 251/300)</p> <p>6 months (82%, n = 246/300)</p> <p>1 year (78%, n = 235/300)</p>	<ul style="list-style-type: none"> Fracture type: Primary osteoporosis with 1 or more osteoporotic vertebral fractures Fracture age: >12 months Number of prevalent fractures: KP: 1, n = 4; 2-3, n = 6; >3, n = 30 Conservative: 1, n = 3; 2-3, n = 3; >3, n = 14 Other diagnoses (KP): Cardiovascular n = 19 Hypertension, n = 22 Pulmonary, n = 8 Inflammatory, n = 6 Others, n = 46 Number of medications, n = 241 Other diagnoses (conservative): Cardiovascular, n = 15 Hypertension, n = 10 Pulmonary, n = 5 Inflammatory, n = 3 Others, n = 19 Number of medications, n = 140 Fracture distribution: KP: T₉-T₁₂, n = 12 L₁-L₄, n = 60 Conservative: T₉-T₁₂, n = 10 L₁-L₄, n = 23 Crossover: NR 	<ul style="list-style-type: none"> KP using PMMA or calcium phosphate cement Conservative treatment All patients received a standard daily dose of aminobisphosphonate, 1000mg calcium, and 1000 IE vitamin D₃ All patients were recommended supervised physiotherapy once a week for 6 months 	<ul style="list-style-type: none"> Midline vertebral height Kyphosis angle New vertebral fractures VAS pain scale European Vertebral Osteoporosis Study (EVOS) questionnaire Pain medication Adverse events
Ki Chan An (2008)	Retrospective cohort	January 2004 to April 2006	<p><u>KP</u> n = 12 female: 100% mean age: 78 years age range: 66-84 years BMI: NR</p>	>1 year (%NR)	<ul style="list-style-type: none"> Fracture type: osteoporotic Fracture distribution: KP: thoracic, n = 5; lumbar, n = 8 Conservative: NR Posterior instrumentation: NR All patients in KP group were senile 	<ul style="list-style-type: none"> KP using fluoroscopy and PMMA Conservative Posterior instrumentation and bone fusion 	<ul style="list-style-type: none"> VAS pain score Kyphotic deformity angle Cement leakage Mobility was evaluated using Chen and Lee's

			<p><u>Conservative</u> n = 33 female: NR mean age: 80 years age range: 64-88 years BMI: NR</p> <p><u>Posterior instrumentation and bone fusion</u> n = 13 female: NR mean age: 74 age range: 60-81 years BMI: NR</p>		<ul style="list-style-type: none"> • Other diagnoses (KP only): Diabetes n = 5 Cardiovascular disease n = 3 COPD: n = 1 Diabetes and cardiovascular disease: n = 3 • Fracture age: NR • Crossover: NR 		semiquantitative scale*
Zampini (2010)	Retrospective cohort A Nationwide Inpatient Sample (NIS)	NR	<p><u>KP</u> n = 882 fractures female: 16.3% mean age: 80 years BMI: NR</p> <p><u>Conservative</u> n = 4884 fractures female: NR mean age: 81.3 BMI: NR</p>	NR	<ul style="list-style-type: none"> • Fracture type: non-neoplastic osteoporotic • Fracture age: acute and subacute (not defined further) • Fracture distribution: KP: thoracic 16.9%; lumbar 14.5% Conservative: NR • Metropolitan hospital: KP 17.4% Conservative: NR • Nonmetropolitan hospital: KP 7.7% Conservative: NR • Deyo-modified Charlson Comorbidity Index <u>KP</u> 0 = 36.3% 1 = 27.4% 2 = 20.8% 3+ = 15.5% <u>Conservative</u> 0 = 36.7% 1 = 29.9% 2 = 19.6% 3+ = 13.7% 	<ul style="list-style-type: none"> • KP using fluoroscopy and PMMA • Conservative 	<ul style="list-style-type: none"> • Discharge location • Complication rates • In-hospital mortality rates • Economic (length of stay, cost of hospitalization)

					<ul style="list-style-type: none"> Number of procedures: KP: mean 2.1 Conservative: mean 0.6 Crossover: NR 		
Kyphoplasty vs, pedicle screw							
Ming (2007)	Retrospective cohort	September 2003 to December 2005	<p><u>KP:</u> n = 30 female: 60% mean age: 64 years age range: 42-78 years BMI: NR</p> <p><u>Pedicle screw:</u> n = 56 female: 57% mean age: 62 years age range: 36-72 years BMI: NR</p>	1 year (%NR)	<ul style="list-style-type: none"> Fracture type: osteoporotic Fracture age: NR Crossover: NR 	<ul style="list-style-type: none"> Kyphoplasty performed using the Sky bone expander system under local or systemic anesthesia, PMMA injected under fluoroscopic surveillance Pedicle screw (PS) using general anesthesia under fluoroscopic surveillance 	<ul style="list-style-type: none"> Vertebral height VAS pain score Bone cement injection volume, distribution, and leakage PS position in the vertebral body

COPD: chronic obstructive pulmonary disease; EQ-5D: European Quality of Life-5 Dimensions scale; KP: Kyphoplasty; NR = not reported; PMMA: polymethylmethacrylate; RDQ: Roland-Morris Disability Questionnaire; SF-36: Medical Outcomes Short Form-36 questionnaire; PCS: Physical Component Score of the SF-36; PVP: percutaneous vertebroplasty; VAS: visual analog scale.

*0, walking without assistance; 1, walking with assistance; 2, wheelchair-bound; 3, activity restricted to sitting in bed; 4, activity restricted to laying flat in bed

Table 6: Characteristics of nonrandomized studies comparing balloon kyphoplasty with percutaneous vertebroplasty.

Author (year)	Study design (LoE)	Study period	Demographics	Follow-up (% followed)	Characteristics	Interventions	Outcomes
Santiago (2010)	Prospective cohort	NR	<p><u>KP</u> n = 30 female: 70% age: 65.9 ± 1.9 years</p> <p><u>PVP</u> n = 30 female: 83% age: 73.0 ± 1.5</p>	1 year (%NR)	<ul style="list-style-type: none"> Fracture type: non-traumatic or low-energy primary osteoporotic (secondary excluded) vertebral fractures Fracture age?/duration of pain KP: 77.3 ± 8.8 days PVP: 126.8 ± 27.1 days Total fractures: 111 (42 KP; 69 PVP) Fracture location (patients/fractures): KP: T1-T10, n = 4/5; T11-T12, n = 14/16; L3-L5, 5/6; multiple, 7/15 PVP: T1-T10, n = 5/7; T11-T12, n = 14/30; L3-L5, 4/5; multiple, 7/27 Crossover: NR 	<ul style="list-style-type: none"> KP using bilateral transpedicular approach and under general anesthesia PVP using extrapedicular approach (n = 9) and bilateral transpedicular approach (n = 21) under general anesthesia (n = 20) or local anesthetic (n = 10) PMMA bone cement 	<ul style="list-style-type: none"> VAS for pain ODI Vertebral height restoration Cement extravasation
Lovi (2009)*	Prospective cohort	January 2003 to January 2005	<p><u>KP</u>: n = 36</p> <p><u>PVP</u>: n = 118</p> <p><u>Total population</u> Female: 64% Age: 67.6 years (53–95)</p>	2.8 years (2.3–3.3) (94%)	<ul style="list-style-type: none"> Fracture type: osteoporotic (primary and secondary) Fracture age (mean) KP: mean 46 days (34–91) PVP: mean 122 days (44–240) 199 fractured levels Number of levels treated per patient: 1.86 (1–4) Multiple levels operated: 68% (n = 104/154) Crossover: NR 	<ul style="list-style-type: none"> KP and PVP via a transpedicular approach for level caudal to T10 and via an extrapedicular approach for levels cranial to T10 PMMA (average 2.5 ml per vertebra) 	<ul style="list-style-type: none"> VAS for pain ODI Vertebral height restoration Complications (cement leakage, incident vertebra fracture)
Röllinghoff (2009)	Prospective cohort	January 2005 to December 2007	N = 90 Female: NR Age: 68.9 ± 10.4 years	1 year (97.8%)	<ul style="list-style-type: none"> Painful, fresh, osteoporotic vertebral fractures showing bone edema Fracture types: impression fracture (A1.1), kyphotic fracture (A1.1), and only for KP the impression fracture with posterior edge involvement without dislocation (A3.1) Fracture age: “fresh” (not further defined) Total fractures treated: 104 (53 KP; 51 PVP) Crossover: NR 	<ul style="list-style-type: none"> KP using the system designed by Medtronic, Inc. PVP using the Advanced Cement Mixing Percutaneous System by Stryker Transpedicular approach for levels L5 to T12 and an extrapedicular approach for levels T11 to T4. 	<ul style="list-style-type: none"> VAS for pain ODI Vertebral height restoration Complications (cement leakage, incident vertebra fracture)

Schofer (2009)	Prospective cohort	2002 to 2004	<p><u>KP</u> n = 35 female: 73%† age: 72.5 ± 5.7 years (63–84)†</p> <p><u>PVP</u> n = 36 female: 80%† age: 73.8 ± 6.4 years (63–86)†</p>	1 year (0.3-3.0) (85%)	<ul style="list-style-type: none"> Fracture type: fresh osteoporotic; dislocated, of the type A1 or A3 (classification of Magerl et al) Fracture age: ≤ 28 days old Fracture location: T6-L-4 Crossover: NR 	<ul style="list-style-type: none"> KP and PVP via a bilateral transpedicular approach, under continuous fluoroscopy, with patients intubated and under general anesthesia, and using PMMA bone cement 	<ul style="list-style-type: none"> VAS for pain SF-36 (German interview version) Radiographs (angle of kyphosis) Cement leakage, balloon rupture Other complications
DeNegri (2007)	Prospective cohort	July 2004 and July 2005	<p><u>KP</u> n = 11 female: NR age: NR</p> <p><u>PVP</u> n = 10 female: NR age: NR</p>	6 months (%NR)	<ul style="list-style-type: none"> Fracture type: osteoporosis or trauma at the thoracic or lumbar levels not responding to chronic pain medication Total levels: 33 (15 KP; 18 PVP) Fracture location: KP: thoracic, n = 11; lumbar, n = 4 PVP: thoracic, n = 6; lumbar, n = 12 Fracture age: < 6 months Crossover: NR 	<ul style="list-style-type: none"> KP using bilateral access (transpedicular or extrapedicular) PVP using unilateral approach PMMA bone cement Heavy sedation or general anesthesia 	<ul style="list-style-type: none"> VAS for pain ODI Complications (cement leakage, incident vertebral fracture)
Grohs (2005)	Prospective cohort	NR	<p><u>KP</u> n = 28 female: NR age: 70 years (65–74)</p> <p><u>PVP</u> n = 23 female: NR age: 70 years (64–77)</p>	2 years (%NR)	<ul style="list-style-type: none"> Fracture type: osteoporotic (primary or secondary) compression fractures of the thoracic or lumbar spine of type A classification (Magerl, et al) Total fractures: 64 (35 KP; 29 PVP) Fracture age (median) KP: 8 weeks PVP: 9 weeks Duration of pain KP: 20 weeks (19–22) PVP: 12 weeks (4–12) Kyphotic wedge KP: 13° (10°–16°) PVP: 13° (10°–17°) Height (%) KP: 80 (74–85) PVP: 83 (74–88) Crossover: NR 	<ul style="list-style-type: none"> KP and PVP using transpedicular approach between T9 and L5 and by extrapedicular approach in the upper thoracic spine Both treatments done under local anesthesia and using PMMA bone cement 	<ul style="list-style-type: none"> VAS for pain ODI Vertebral height restoration Complications (cement leakage, incident vertebra fracture)

Lee (2010)	Retrospective cohort	March 2005 to March 2008	<p><u>KP</u> n = 59 female: NR age: NR</p> <p><u>PVP</u> n = 24 female: NR age: NR</p>	within 2 months postop (100%)	<ul style="list-style-type: none"> NR 	<ul style="list-style-type: none"> KP PVP 	<ul style="list-style-type: none"> Cement leakage
Hiwatashi (2009)	Retrospective cohort	2001 to 2007	<p><u>KP</u> n = 40 male: 73% age: 75 years (45–97)</p> <p><u>PVP</u> n = 66 female: 68% age: 77 years (45–93)</p>	Postop (100%)	<ul style="list-style-type: none"> Fracture type: osteoporotic (non-neoplastic); unresponsive to conservative treatment Total fractures treated: 181 (57 KP; 124 PVP) Fracture age: NR Fracture levels: <ul style="list-style-type: none"> <u>KP</u> T7, n = 2; T9, n = 2; T10, n = 1; T11, n = 3; T12, n = 12; L1, n = 13; L2, n = 10; L3, n = 10; L4, n = 4 <u>PVP</u> T6, n = 1; T7, n = 5; T8, n = 5; T9, n = 8; T10, n = 11; T11, n = 16; T12, n = 15; L1, n = 30; L2, n = 10; L3, n = 11; L4, n = 12 Crossover: NR 	<ul style="list-style-type: none"> KP through a bipedicular approach under continuous fluoroscopy; used PMMA bone cement mixed with barium sulfate PVP through a transpedicular approach under continuous fluoroscopy; used PMMA Both procedures done by the same operator, under local anesthesia, and with patient under moderate sedation 	<ul style="list-style-type: none"> Vertebral body height and wedge angle Cement leakage
Muto (2008)	Retrospective cohort	April 2001 to December 2006	<p><u>KP</u> n = 39 female: 18% age: 42 years</p> <p><u>PVP</u> n = 485 female: 58% age: 59 years</p>	6 months (100%)	<ul style="list-style-type: none"> Fracture type: <ul style="list-style-type: none"> KP: traumatic vertebral fractures according to Magerl's classification A1 (n = 30) and A3 (n = 9) PVP: osteoporotic (n = 310), vertebral metastasis (n = 160), and vertebral haemangioma (n = 15) Fracture age <ul style="list-style-type: none"> KP: ≤ 3 months PVP: NR Crossover: NR 	<ul style="list-style-type: none"> KP through a bilateral transpedicular approach, using general or local neuroleptanalgesia PVP through either unilateral transpedicular or a bilateral approach using only local anesthesia combined with neuroleptanalgesia 	<ul style="list-style-type: none"> VAS pain scale Oswestry Disability Index

Zhou (2008)	Retrospective cohort	August 2002 to April 2006	<p><u>KP</u> n = 42 female: 60% age: 64 years (31-74)</p> <p><u>PVP</u> n = 56 female: 62% age: 62 years (28-73)</p>	Postop (100%)	<ul style="list-style-type: none"> • Fracture type: osteoporotic • Fracture age: NR • Crossover: NR 	<ul style="list-style-type: none"> • PVP • KP patients were treated using the Sky bone expander system • Both procedures were performed under general or local anesthesia, using PMMA under fluoroscopic guidance 	<ul style="list-style-type: none"> • Vertebral body height • VAS score • Cement volume, distribution, and leakage
Frankel (2007)	Retrospective cohort	NR	<p><u>KP</u> n = 17 female: NR age: 70 years (46–83)</p> <p><u>PVP</u> n = 19 female: NR age: 72 years (38–90)</p>	3.5 years (%NR)	<ul style="list-style-type: none"> • Fracture type: osteoporotic (non-neoplastic); unresponsive to conservative treatment • Total vertebra treated: 46 (20 KP; 26 PVP) • Levels treated: 1 level, n = 28; 2-3 levels, n = 8 • Unilateral augmentation KP: n = 1 (5%) PVP: n = 21 (81%) • Bilateral augmentation KP: n = 19 (95%) PVP: n = 5 (19%) • Fracture age: NR • Crossover: NR 	<ul style="list-style-type: none"> • KP using the Kyphon system and standard techniques (not described) • PVP using the Pedestal fenestrated tap system under continuous fluoroscopy; PMMA cement mixed with barium sulfate 	<ul style="list-style-type: none"> • Comparative pain rating scale‡ • Radiographs • Cement extravasation and leakage • Adjacent level fractures
Köse (2006)	Retrospective cohort	June 2003 to June 2005	<p><u>KP</u> n = 18 female: 50% age: 64 years (48–82)</p> <p><u>PVP</u> n = 16 female: 56% age: 62 years (45–80)</p>	1 year (100%)	<ul style="list-style-type: none"> • Fracture type: symptomatic fractures due to primary multiple myelomas; unresponsive to conservative treatment • Total vertebral treated: 50 (22 KP; 28 PVP) • Fracture distribution: KP: 15 lumbar, 7 thoracic PVP: 13 lumbar, 15 thoracic • Fracture age: NR • Crossover: NR 	<ul style="list-style-type: none"> • KP and PVP using PMMA bone cement mixed with barium • Both procedure used continuous fluoroscopy and local anesthesia with patient under moderate sedation 	<ul style="list-style-type: none"> • VAS for pain • Analgesic use • Adjacent level collapse or other complications
Fourney (2003)	Retrospective cohort	October 2000-February 2002	<p><u>KP</u> n = 15 female: 47% age: NR</p> <p><u>PVP</u></p>	median follow up: 4.5 months Patients available at each interval;	<ul style="list-style-type: none"> • Fracture type: pathological; symptomatic • Most common cancer diagnosis: multiple myeloma (KP 40%;PVP 32%; KP and PVP 57%) 	<ul style="list-style-type: none"> • KP through a bilateral approach • PVP through a unilateral approach was used in most cases 	<ul style="list-style-type: none"> • Pain relief • Decrease in the category of analgesic usage • Subjective improvement in ambulatory capacity

			<p>n = 34 female: 44% age: NR</p> <p><u>KP & PVP</u> n = 7 female: 43% age: NR</p>	<p>1 month, n = 41 (73%); 3 months, n = 37 (66%); 6 months, n = 121 (38%); 1 year, n = 8 (14%)</p>	<ul style="list-style-type: none"> • Median duration of spinal pain: 3.2 months (1 week to 26 months) • Several patients had risk factors for osteoporosis, it was often difficult to determine the extent to which this was responsible for vertebral body collapse compared with a purely osteolytic malignant process • Mean spinal levels treated per session: 1.7(1-5) • Most common level: thoracolumbar junction • Previous treatment: <i>Chemotherapy:</i> 87% KP, 79% PVP, 100% KP & PVP <i>Spinal radiotherapy:</i> 33% KP, 29% PVP, 43% KP & PVP <i>Spinal operation:</i> 27% KP, 6% PVP, 0 KP & PVP <i>PVP or KP:</i> 0 KP, 0 PVP, 14% KP & PVP • Fracture age: NR • Crossover: NR 	<ul style="list-style-type: none"> • A transpedicular approach was preferred in both procedures • General or local anesthesia was in all cases 	<ul style="list-style-type: none"> • Frankel grades for functional improvement of ambulatory status • Vertebral body height • Kyphosis correction • Complications • Relapse of pain
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AQoL: Assessment of Quality of Life questionnaire; DPQ: Dallas Pain Questionnaire; EQ-5D: European Quality of Life-5 Dimensions scale; MMSE: mini-mental state exam; NR = not reported; NSAIDs: non-steroidal anti-inflammatory drugs; ODI: Oswestry Disability Index; OPM: optimal pain medication; PMMA: polymethylmethacrylate; QUALEFFO: Quality of Life Questionnaire of the European Foundation for Osteoporosis; RDQ: Roland-Morris Disability Questionnaire; SF-36: Medical Outcomes Short Form-36 questionnaire; SOF-ADL: Study of Osteoporotic Fractures-Activities of Daily Living; VAS: visual analog scale.

*Lovi 2009 originally included 164 surgically treated patients and stated that 10 were lost to follow-up resulting in a cohort of 154 (36 KP; 118 PVP) for which demographics are given only. Demographics were not given for each group separately but the author states that gender distribution, age, and follow-up did not differ significantly between the two groups.

†Age and gender data were given for the treatment groups only after loss to follow-up (n = 30 in each group).

‡Pain score: 1 = no pain/no analgesics, 2 = reduced pain/taking analgesics; 3 = no change in pain postoperatively; 4 = worse pain postoperatively.

APPENDIX G: DATA TABLES: Clinical results for comparative studies

Table 1: Results of RCTs comparing percutaneous vertebroplasty with other treatments

Study (year)	Functional outcomes	Pain	QoL	Safety
Klazen, Lohle, de Vries, et al. (2010)/ Klazen, Venmans, de Vries, et al (2010)/ Venmans, Klazen, van Rooij, et al. (2010)/ Venmans, Klazen, Lohle, et al (2010) VERTOS II	RMD* <u>PV</u> preop: 18.6 (± 3.6) 1 day: 18.5 1 week: 13.0 1 month: 11.8 3 months: 10.0 6 months: 9.8 1 year: 9.2 <u>Conservative</u> preop: 17.2 (± 4.2) 1 day: 16.9 1 week: 15.2 1 month: 13.5 3 months: 12.6 6 months: 11.2 1 year: 11.2 Improvement with time was significantly greater and quicker after PV than conservative care ($P < .0001$)	VAS <u>PV</u> preop: 7.8 (± 1.5) 1 day: 3.7 (± 2.4) 1 week: 3.5 (± 2.5) 1 month: 2.5 (± 2.5) 3 months: 2.5 (± 2.7) 6 months: 2.3 (± 2.7) 1 year: 2.2 (± 2.7) <u>Conservative</u> preop: 7.5 (± 1.6) 1 day: 6.7 (± 2.1) 1 week: 5.6 (± 2.5) 1 month: 4.9 (± 2.6) 3 months: 3.9 (± 2.8) 6 months: 3.9 (± 2.9) 1 year: 3.8 (± 2.8) For intergroup comparisons: $P < .001$ at 1 day, 1 week, and 1 month; $P = .025$ at 3 months; $P = .014$ at 6 months and 1 year Difference in mean VAS score <u>PV</u> preop and 1 month: -5.2 (95% CI, -5.88 to -4.72) preop and 1 year: -5.7 (95% CI, -6.22 to -4.98) <u>Conservative</u> preop and 1 month: -2.7 (95%	QUALEFFO* <u>PV</u> preop: 58.7 (± 13.5) 1 day: 59 1 week: 45 1 month: 43 3 months: 40 6 months: 40 1 year: 42 <u>Conservative</u> preop: 54.7 (± 14.4) 1 day: 54 1 week: 50 1 month: 47 3 months: 45 6 months: 44 1 year: 44 Improvement with time was significantly greater and quicker after PV than conservative care ($P < .0001$)	Cement leakage postprocedure <i>Any:</i> 80% (64/80 vertebra); 95% CI, 70%–87% Discal: 34% (n = 22) Discal + venous: 13% (n = 8) Soft-tissue: 4% (n = 2) <i>Into the paravertebral venous system:</i> 88% (56/64 vertebra) Anterior external venous plexus: 82% (46/56), in combination with cement in the segmental vein: 57% (32/56); Inferior caval vein: 9% (5/56); Azygos vein: 11% (6/56); Basivertebral vein: 54% (30/56); Anterior internal venous plexus: 59% (33/56); Both basivertebral vein and anterior internal venous plexus: 46% (26/56); Intervertebral vein: 5% (3/56); Posterior internal and external venous plexus: 0% Cement leakage at follow-up Comparison of follow-up and baseline CTs showed unchanged anatomical location of the perivertebral cement leakages in all vertebra without late cement

		<p>CI, -3.22 to -1.98) preop and 1 year: -3.7 (95% CI, -4.35 to -3.05)</p> <p><u>Between PV and conservative</u> preop and 1 month: 2.6 (95% CI, 1.74–3.37; $P < .0001$) preop and 1 year: 2.9 (95% CI, 1.13–2.80; $P < .0001$)</p> <p>Survival analysis showed that significant pain relief ($\chi^2 = 55.6$; $P < .0001$) was achieved earlier and in more patients after PV than conservative treatment (29.7 days vs. 115.6 days)</p> <p>Drug usage for pain relief Significantly reduced after PV compared with conservative treatment at 1 day ($P < .0001$), 1 week ($P = .001$), and 1 month ($P = .033$) but not at later stages of follow-up.</p>		<p>migration</p> <p>Location of treated vertebra No statistical relation between location of the treated vertebra and the occurrence of perivertebral cement leakage was found, $P = .64$</p> <p>Mean volume of injected cement in vertebra: with leakage (n = 47): $4.5 \pm 1.8 \text{ cm}^3$ without leakage (n = 33): $3.7 \pm 1.6 \text{ cm}^3$ $P = .04$; 95% CI, -1.58% to -0.02%)</p> <p>Pulmonary cement embolism Detected in 14/54 patients (26%; 95% CI, 16%–39%); all patients asymptomatic; none observed in the heart or central pulmonary vessels Single embolus: n = 6/14 (43%); 2–35 emboli: n = 8/14 (57%); Size: ranged from 1–12 mm; Distribution: random</p> <p>New vertebral fractures <u>PV</u>: n = 18 (in 15/91 patients) adjacent: n = 7 between: n = 4 distant: n = 7 <u>Conservative</u>: n = 30 (in 21/85 patients)</p>
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				<p>adjacent: n = 11 between: n = 3 distant: n = 16</p> <p>Further height loss <u>PV (n = 136 vertebra)</u> None (0–3 mm): n = 118 Moderate (4–7 mm): n = 7 Severe (≥ 8 mm): n = 4 <u>Conservative (n = 120 vertebra)</u> None (0–3 mm): n = 74 Moderate (4–7 mm): n = 28 Severe (≥ 8 mm): n = 11 <i>P</i> < .001 for comparison of no height loss between groups</p>
Rousing (2010)†	<p>Tandem test‡ <i>3 months</i> PV: 21.3; 95% CI, 15.1–27.5 Conservative: 19.5; 95% CI, 14.5–24.5 <i>P</i> = .62 <i>12 months</i> PV: 22.4; 95% CI, 16.7–28.1 Conservative: 18.6; 95% CI, 13.6–23.6 <i>P</i> = .29</p> <p>Timed Up & Go‡ <i>3 months</i> PV: 16.0; 95% CI, 12.6–19.4 Conservative: 17.0; 95% CI, 11.9–22.1 <i>P</i> = .75 <i>12 months</i> PV: 16.1; 95% CI, 11.8–20.4 Conservative: 17.3; 95% CI, 12.7–22.0</p>	<p>VAS (1-10) <u>PV</u> <i>preop</i>: 7.5; 95% CI, 6.6–8.4 <i>3 mos</i>: 1.8; 95% CI, 0.8–2.8 <i>P</i> = .00 <i>12 mos</i>: 2.0; 95% CI, 1.1–3.0</p> <p><u>Conservative</u> <i>preop</i>: 8.8; 95% CI, 8.2–9.3 <i>3 mos</i>: 2.6; 95% CI, 1.2–4.0 <i>P</i> = .00 <i>12 mos</i>: 2.9; 95% CI, 1.6–4.1</p> <p>No significant difference between groups at 3 months (<i>P</i> = .33) or 12 months (<i>P</i> = .29)</p>	<p>SF-36 (PCS)§ <u>PV</u> <i>preop</i>: 36.7; 95% CI, 30.0–43.4 <i>3 mos</i>: 34.0; 95% CI, 30.1–37.9 <i>P</i> = .00 <i>12 mos</i>: 32.1; 95% CI, 27.8–36.3</p> <p><u>Conservative</u> <i>preop</i>: 33.4; 95% CI, 26.2–40.7 <i>3 mos</i>: 29.3; 95% CI, 24.5–34.1 <i>P</i> = .01 <i>12 mos</i>: 30.5; 95% CI, 25.2–35.7</p> <p>No significant difference between groups at 3 months (<i>P</i> = .12) or 12 months (<i>P</i> = .63)</p> <p>SF-36 (MCS)§ <u>PV</u> <i>preop</i>: 49.7; 95% CI, 43.6–55.8</p>	<p>Authors mention no adverse events except for extravertebral cement leakage, none of which caused neurological symptoms or led to reoperation; no procedures were converted to open surgery</p> <p>New fractures <i>PV</i>: n = 3 <i>Conservative</i>: n = 1 RR = 2.9 (95% CI, 0.3–25.7)</p> <p>Adjacent fractures <i>PV</i>, n = 2 (2/3 new fractures, 67%) <i>Conservative</i>, n = 0</p>

	<p>$P = .67$</p> <p>Repeated chair test‡ <i>3 months</i> PV: 5.9; 95% CI, 2.8–9.0 Conservative: 5.9; 95% CI, 3.1–8.6 $P = .98$</p> <p><i>12 months</i> PV: 5.4; 95% CI, 3.2–7.5 Conservative: 4.8; 95% CI, 2.3–7.3 $P = .71$</p>		<p><i>3 mos:</i> 48.9; 95% CI, 43.8–54.0 $P = .89$ <i>12 mos:</i> 48.7; 95% CI, 42.7–54.6</p> <p><u>Conservative</u> <i>preop:</i> 49.6; 95% CI, 41.9–57.3 <i>3 mos:</i> 46.2; 95% CI, 39.2–53.2 $P = .88$ <i>12 mos:</i> 49.0; 95% CI, 43.9–54.1</p> <p>No significant difference between groups at 3 months ($P = .51$) or 12 months ($P = .93$)</p> <p>DPQ§ Daily activities <u>PV</u> <i>preop:</i> 47.8; 95% CI, 22.5–73.1 <i>3 mos:</i> 47.1; 95% CI, 32.9–61.4 $P = .75$ <i>12 mos:</i> 53.0; 95% CI, 38.3–67.7</p> <p><u>Conservative</u> <i>preop:</i> 68.5; 95% CI, 47.0–90.1 <i>3 mos:</i> 57.4; 95% CI, 40.7–74.1 $P = .26$ <i>12 mos:</i> 53.6; 95% CI, 34.8–72.5</p> <p>No significant difference between groups at 3 months ($P = .33$) or 12 months ($P = .95$)</p> <p>Work and leisure</p>	
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			<p><u>PV</u> <i>preop</i>: 41.1; 95% CI, 20.7–61.5 <i>3 mos</i>: 44.5; 95% CI, 30.4–58.7 <i>P</i> = .37 <i>12 mos</i>: 46.1; 95% CI, 31.4–60.9</p> <p><u>Conservative</u> <i>preop</i>: 68.7; 95% CI, 47.8–89.6 <i>3 mos</i>: 65.2; 95% CI, 50.4–80.1 <i>P</i> = .35 <i>12 mos</i>: 49.2; 95% CI, 31.5–66.9</p> <p>At 3 months, significantly better outcomes were seen for conservatively treated versus PV patients, <i>P</i> = .04; at 12 months the difference was not significant, <i>P</i> = .78</p> <p><i>Anxiety and depression</i></p> <p><u>PV</u> <i>preop</i>: 31.5; 95% CI, 12.6–50.4 <i>3 mos</i>: 28.7; 95% CI, 15.1–42.3 <i>P</i> = .87 <i>12 mos</i>: 31.3; 95% CI, 16.5–46.2</p> <p><u>Conservative</u> <i>preop</i>: 43.0; 95% CI, 19.9–66.1 <i>3 mos</i>: 40.0; 95% CI, 20.8–59.2 <i>P</i> = .43 <i>12 mos</i>: 35.3; 95% CI, 20.4–20.2</p> <p>No significant difference between</p>	
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			<p>groups at 3 months ($P = .30$) or 12 months ($P = .70$)</p> <p>Social interest</p> <p><u>PV</u> <i>preop</i>: 23.8; 95% CI, 9.9–37.7 <i>3 mos</i>: 24.1; 95% CI, 13.2–35.0 $P = .47$ <i>12 mos</i>: 32.9; 95% CI, 18.9–46.9</p> <p><u>Conservative</u> <i>preop</i>: 41.0; 95% CI, 23.3–58.7 <i>3 mos</i>: 30.7; 95% CI, 15.9–45.5 $P = .09$ <i>12 mos</i>: 30.7; 95% CI, 16.5–44.8</p> <p>No significant difference between groups at 3 months ($P = .46$) or 12 months ($P = .82$)</p> <p>EQ5D‡</p> <p><u>PV</u> <i>preop</i>: 0.356; 95% CI, 0.196–0.516 <i>3 mos</i>: 0.731; 95% CI, 0.653–0.809 $P = .00$ <i>12 mos</i>: 0.675; 95% CI, 0.576–0.775</p> <p><u>Conservative</u> <i>preop</i>: 0.083; 95% CI, 0.151–0.317 <i>3 mos</i>: 0.543; 95% CI, 0.387–0.699</p>	
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			<p>$P = .01$ <i>12 mos</i>: 0.571; 95% CI, 0.448–0.694</p> <p>At 3 months, PV group had significantly better health state ($P = .04$) but the groups differed at inclusion ($P = .05$) and are therefore not comparative; at 12 months the difference was not significant ($P = .19$)</p> <p>Barthel index‡ <u>PV</u> <i>preop</i>: 17.7; 95% CI, 15.6–19.8 <i>3 mos</i>: 19.6; 95% CI, 19.0–20.3 $P = .11$ <i>12 mos</i>: 19.8; 95% CI, 19.5–20.0</p> <p><u>Conservative</u> <i>preop</i>: 17.0; 95% CI, 14.2–19.8 <i>3 mos</i>: 18.1; 95% CI, 16.8–19.4 $P = .41$ <i>12 mos</i>: 18.5; 95% CI, 17.6–19.3</p> <p>No significant difference between groups at 3 months, $P = .07$; at 12 months the difference was significant, $P = .02$</p> <p>MMSE, %‡ <u>PV</u> <i>preop</i>: 86.8; 95% CI, 81.8–91.8 <i>3 mos</i>: 87.2; 95% CI, 79.7–94.7 $P = .64$</p>	
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			<p>12 mos: 88.3; 95% CI, 81.2–95.3</p> <p><u>Conservative</u> <i>preop</i>: 86.5; 95% CI, 81.8–91.3 3 mos: 90.5; 95% CI, 86.9–94.2 <i>P</i> = .12 12 mos: 88.7; 95% CI, 80.6–96.8</p> <p>No significant difference between groups at 3 months (<i>P</i> = .36) and 12 months (<i>P</i> = .93)</p>	
Buchbinder (2009)	<p>RDQ <u>PV</u> <i>preop</i>: 17.3 ± 2.8 change at: 1 week: 1.8 ± 5.0 1 month: 4.4 ± 6.6 3 months: 3.7 ± 5.4 6 months: 4.1 ± 5.8</p> <p><u>Sham</u> <i>preop</i>: 17.3 ± 2.9 change at: 1 week: 4.0 ± 6.8 1 month: 3.1 ± 6.8 3 months: 5.3 ± 7.2 6 months: 3.7 ± 5.8</p> <p><u>Adjusted between-group mean difference (95% CI) at:</u> 1 week: -2.1 (-5.2 to 0.9) 1 month: 1.7 (-1.8 to 5.2) 3 months: -1.5 (-4.8 to 1.7)</p>	<p>VAS (1-10) <u>PV</u> <i>preop</i>: 7.4 ± 2.1; change at: 1 week: 1.5 ± 2.5 1 month: 2.3 ± 2.6 3 months: 2.6 ± 2.9 6 months: 2.4 ± 3.3</p> <p><u>Sham</u> <i>preop</i>: 7.1 ± 2.3; change at: 1 week: 2.1 ± 2.8 1 month: 1.7 ± 3.3 3 months: 1.9 ± 3.3 6 months: 2.1 ± 3.3</p> <p><u>Adjusted between-group mean difference (95% CI) at:</u> 1 week: -0.7 (-1.8 to 0.4) 1 month: 0.5 (-0.8 to 1.7) 3 months: 0.6 (-0.7 to 1.8)</p>	<p>QUALEFFO <u>PV</u> <i>preop</i>: 59.6 ± 13.4 change at: 1 week: -0.5 ± 7.4 1 month: 2.8 ± 9.3 3 months: 6.0 ± 9.6 6 months: 6.4 ± 13.4</p> <p><u>Sham</u> <i>preop</i>: 59.6 ± 17.1 change at: 1 week: 3.6 ± 9.2 1 month: 2.4 ± 12.3 3 months: 6.1 ± 13.7 6 months: 6.1 ± 13.4</p> <p><u>Adjusted between-group mean difference (95% CI) at:</u> 1 week: -4.0 (-7.8 to 0.2) 1 month: 0.9 (-4.2 to 6.0) 3 months: 0.7 (-4.4 to 5.7)</p>	<p>Cement leakage (minimal), 37% (n = 14)</p> <p>Incident fracture <u>PV</u> total, n = 6 vertebra, n = 3 (1 at 1 week, 1 month, and 6 months each) hip, n = 1 (at 3 months) rib, n = 2 (1 at 1 week and 3 months each) pelvis, n = 0</p> <p><u>Sham</u> total, n = 9 vertebra, n = 4 (3 at 1 month; 1 at 3 months) hip, n = 0 rib, n = 4 (2 at 1 week; 2 at 6 months) pelvis, n = 1 (at 1 month)</p> <p>Osteomyelitis</p>

	<p>6 months: 0.0 (-3.0 to 2.9)</p>	<p>6 months: 0.1 (-1.2 to 1.4)</p> <p>Perceived Pain**</p> <p><u>PV</u></p> <p>1 week</p> <p>better: 16% (n = 6) no change: 70% (n = 26) worse: 14% (n = 5)</p> <p>1 month</p> <p>better: 34% (n = 12) no change: 60% (n = 21) worse: 6% (n = 2)</p> <p>3 months</p> <p>better: 39% (n = 14) no change: 53% (n = 19) worse: 8% (n = 3)</p> <p>6 months</p> <p>better: 46% (n = 16) no change: 34% (n = 12) worse: 20% (n = 7)</p> <p><u>Sham</u></p> <p>1 week</p> <p>better: 35% (n = 13) no change: 62% (n = 23) worse: 3% (n = 1)</p> <p>1 month</p> <p>better: 24% (n = 9) no change: 53% (n = 20) worse: 24% (n = 9)</p> <p>3 months</p> <p>better: 32% (n = 12) no change: 49% (n = 18) worse: 19% (n = 7)</p> <p>6 months</p> <p>better: 42% (n = 15) no change: 44% (n = 16)</p>	<p>6 months: 0.6 (-5.7 to 6.2)</p> <p>AQoL</p> <p><u>PV</u></p> <p>preop: 0.33 ± 0.25</p> <p>change at:</p> <p>1 week: 0.0 ± 0.2 1 month: 0.0 ± 0.2 3 months: 0.0 ± 0.2 6 months: 0.0 ± 0.3</p> <p><u>Sham</u></p> <p>preop: 0.27 ± 0.26</p> <p>change at:</p> <p>1 week: 0.0 ± 0.2 1 month: 0.1 ± 0.3 3 months: 0.1 ± 0.3 6 months: 0.1 ± 0.3</p> <p><u>Adjusted between-group mean difference (95% CI) at:</u></p> <p>1 week: 0.0 (-0.1 to 0.1) 1 month: 0.0 (-0.1 to 0.1) 3 months: 0.0 (-0.1 to 0.1) 6 months: 0.1 (-0.1 to 0.2)</p> <p>EQ5D</p> <p><u>PV</u></p> <p>preop: 0.30 ± 0.32</p> <p>change at:</p> <p>1 week: 0.1 ± 0.3 1 month: 0.1 ± 0.3 3 months: 0.2 ± 0.3 6 months: 0.2 ± 0.4</p> <p><u>Sham</u></p> <p>preop: 0.28 ± 0.33</p>	<p><u>PV</u>, n = 1 at 1 month <u>Sham</u>, n = 0</p> <p>Tightness in the back or rib cage</p> <p><u>PV</u>, n = 1 (at 1 month) <u>Sham</u>, n = 2 (at 3 months)</p> <p>Pain or burning in thigh or leg</p> <p><u>PV</u>, n = 4 (3 at 1 week; 1 at 3 months) <u>Sham</u>, n = 2 (1 at 1 week; 1 at 3 months)</p> <p>Stomach pain</p> <p><u>PV</u>, n = 2 (1 at 1 week; 1 at 6 months) <u>Sham</u>, n = 1 (at 3 months)</p> <p>Increased pain or muscle cramping around puncture site</p> <p><u>PV</u>, n = 2 (1 at 1 week, 1 at 3 months) <u>Sham</u>, n = 1 (at 6 months)</p> <p>Chest pain</p> <p><u>PV</u>, n = 3 (all at 1 week) <u>Sham</u>, n = 0</p>
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		<p>worse: 14% (n = 5)</p> <p><u>RR (95% CI) for the comparison of “better” (successful outcome) with “no change” or “worse” at:</u></p> <p><i>1 week: 0.5 (0.2 to 1.1)</i> <i>1 month: 1.5 (0.7 to 3.0)</i> <i>3 months: 1.2 (0.6 to 2.2)</i> <i>6 months: 1.1 (0.6 to 1.9)</i></p>	<p>change at:</p> <p><i>1 week: 0.1 ± 0.3</i> <i>1 month: 0.1 ± 0.3</i> <i>3 months: 0.2 ± 0.4</i> <i>6 months: 0.2 ± 0.4</i></p> <p><u>Adjusted between-group mean difference (95% CI) at:</u></p> <p><i>1 week: 0.0 (-0.1 to 0.2)</i> <i>1 month: 0.0 (-0.1 to 0.1)</i> <i>3 months: 0.0 (-0.1 to 0.2)</i> <i>6 months: 0.0 (-0.1 to 0.2)</i></p>	
Kallmes (2009)	<p>RDQ</p> <p><u>PV</u> <i>preop: 16.6 ± 3.8</i> <i>3 days: 13.0 ± 5.2</i> <i>2 weeks: 12.4 ± 5.8</i> <i>1 month: 12.0 ± 6.3</i></p> <p><u>Sham</u> <i>preop: 17.5 ± 4.1</i> <i>3 days: 12.5 ± 5.5</i> <i>2 weeks: 12.3 ± 5.9</i> <i>1 month: 13.0 ± 6.4</i></p> <p><u>Treatment effect (95% CI) at:</u> <i>3 days: -0.9 (-2.7 to 0.8); P = .30</i> <i>2 weeks: -0.6 (-2.4 to 1.2); P = .35</i> <i>1 month: 0.7 (-1.3 to 2.8); P = .49</i></p>	<p>VAS (1-10)</p> <p><u>PV</u> <i>preop: 6.9 ± 2.0</i> <i>3 days: 4.2 ± 2.8</i> <i>2 weeks: 4.3 ± 2.9</i> <i>1 month: 3.9 ± 2.9</i></p> <p><u>Sham</u> <i>preop: 7.2 ± 1.8</i> <i>3 days: 3.9 ± 2.9</i> <i>2 weeks: 4.5 ± 2.8</i> <i>1 month: 4.6 ± 3.0</i></p> <p><u>Treatment effect (95% CI) at:</u> <i>3 days: -0.4 (-1.5 to 0.5); P = .37</i> <i>2 weeks: 0.1 (-0.8 to 1.1); P = .77</i> <i>1 month: 0.7 (-0.3 to 1.7); P = .19</i></p> <p>Pain Frequency Index score^{††}</p> <p><u>PV</u> <i>preop: 3.0 ± 0.8</i> <i>1 month: 2.1 ± 1.2</i></p> <p><u>Sham</u> <i>preop: 3.1 ± 0.8</i></p>	<p>SF-36 (PCS)</p> <p><u>PV</u> <i>preop: 25.3 ± 7.8</i> <i>1 month: 29.7 ± 9.6</i></p> <p><u>Sham</u> <i>preop: 25.3 ± 7.3</i> <i>1 month: 28.7 ± 8.0</i></p> <p><u>Treatment effect: 0.2 (95% CI, -1.7 to 3.7; P = .45)</u></p> <p>SF-36 (MCS)</p> <p><u>PV</u> <i>preop: 44.8 ± 11.8</i> <i>1 month: 46.9 ± 12.0</i></p> <p><u>Sham</u> <i>preop: 41.5 ± 14.1</i> <i>1 month: 45.6 ± 14.8</i></p> <p><u>Treatment effect: 1.0 (95% CI, -3.7 to 4.6; P = .83)</u></p> <p>EQ5D</p>	<p><u>PV</u>, n = 1 injury to the thecal sac during operation requiring hospitalization</p> <p><u>Sham</u>, n = 1 tachycardia and rigors of unknown origin following procedure</p>

		<p><i>1 month: 2.3 ± 1.1</i></p> <p><u>Treatment effect:</u> 0.2 (95% CI, -0.2 to 0.6; <i>P</i> = .33)</p> <p>Pain Bothersome Index score^{††}</p> <p><u>PV</u> <i>preop: 2.9 ± 0.7</i> <i>1 month: 1.9 ± 1.1</i></p> <p><u>Sham</u> <i>preop: 3.1 ± 0.8</i> <i>1 month: 2.1 ± 1.1</i></p> <p><u>Treatment effect:</u> 0.2 (95% CI, -0.2 to 0.6; <i>P</i> = .33)</p> <p>Opioid use</p> <p><u>PV</u> <i>preop: 56% (n = 38)</i> <i>1 month: 54%</i></p> <p><u>Sham</u> <i>preop: 63% (n = 40)</i> <i>1 month: 43%</i></p> <p><u>Treatment effect:</u> 1.15 (95% CI, 0.98 to 1.35; <i>P</i> = .08)</p>	<p><u>PV</u> <i>preop: 0.57 ± 0.18</i> <i>1 month: 0.70 ± 0.18</i></p> <p><u>Sham</u> <i>preop: 0.54 ± 0.23</i> <i>1 month: 0.64 ± 0.20</i></p> <p><u>Treatment effect:</u> 0.05 (95% CI, -0.01 to 0.11; <i>P</i> = .13)</p> <p>SOF-ADL</p> <p><u>PV</u> <i>preop: 10.0 ± 3.6</i> <i>1 month: 7.7 ± 3.7</i></p> <p><u>Sham</u> <i>preop: 10.3 ± 2.8</i> <i>1 month: 8.2 ± 3.6</i></p> <p><u>Treatment effect:</u> 0.4 (95% CI, -0.8 to 1.6; <i>P</i> = .51)</p>	
Voormolen (2007) VERTOS also	RDQ <u>PV</u> <i>preop: 15.7 (8-22)</i> <i>2 weeks: 13 (3-22)</i> <i>change (%): 19</i>	VAS (1-10) <u>PV</u> <i>preop: 7.1 (5-9)</i> <i>1 day: 4.7 (1-8)</i> <i>change: -2.3</i> <i>2 weeks: 4.9 (0-10)</i>	QUALEFFO <u>PV</u> <i>preop: 60 (37-85)</i> <i>2 weeks: 53 (28-79)</i> <i>change: -6.8</i>	None

<p>included outcomes in a subset of patients who crossed over from OPM to PV</p>	<p><u>OPM</u> preop: 17.8 (9-24) 2 weeks: 18 (9-23) change(%): -2</p> <p><u>Difference PV-OPM (95% CI) at 2 weeks: -5 (-8.4 to -1.2)</u></p> <p><u>Difference in change(%) PV-OPM (95% CI) at 2 weeks: 21 (0.07-0.35)</u></p>	<p>change vs. preop: -2.1 change vs. 1 day: +0.2</p> <p><u>OPM</u> preop: 7.6 (5-10) 1 day: 7.1 (5-10) 2 weeks: 6.4 (3-9) change vs. preop: -1.1 change vs. 1 day: -0.6</p> <p><u>Difference PV-OPM (95% CI) at:</u> 1 day: -2.4 (-3.7 to -1.0) 2 weeks: -1.5 (-3.2 to 0.2)</p> <p><u>Difference in change PV-OPM (95% CI) from:</u> preop to 1 day: -1.8 (-2.9 to -.08) preop to 2 weeks: -1.0 (-0.5 to 2.5) 1 day to 2 weeks: 0.8 (-2.4 to 0.7)</p> <p>Analgesic use†† <u>PV</u> preop: 1.9 (0-3) 1 day: 1.1 (0-3) change: -0.8 2 weeks: 1.2 (0-3) change vs. preop: -0.7 change vs. 1 day: -0.2</p>	<p><u>OPM</u> preop: 67 (38-86) 2 weeks: 67 (40-88) change: -0.7</p> <p><u>Difference PV-OPM (95% CI) at 2 weeks: -14 (-24.7 to -3.4)</u></p> <p><u>Difference in change PV-OPM (95% CI) at 2 weeks: -6.1 (-10.7 to -1.6)</u></p>	
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AQoL: Assessment of Quality of Life; DPQ: Dallas Pain Questionnaire; EQ5D: European Quality of Life-5 Dimensions; MMSE: mini-mental state examination; NSAIDs: non-steroidal anti-inflammatory drugs; OVCF: osteoporotic vertebral compression fractures; PCS: Standardized Physical Component; MCS: Standardized Mental Component; PV: percutaneous vertebroplasty; QoL: quality of life; QUALEFFO: Quality of Life Questionnaire of the European Foundation for Osteoporosis; RDQ: Roland Morris Disability Questionnaire; RR: Relative Risk; SOF-ADL: Study of Osteoporotic Fractures-Activities of Daily Living scale. *Scores at 1 day, 1 week, 1 month, 3 months, 6 months, and 1 year for the RDQ and the QUALEFFO were estimated from figures provided in the article.

†Pre-operative and 3 month data are from the original study published in 2009.

‡These outcomes were included following November 2004 when a PhD-study was affiliated to the project.

§Only patients with acute fractures answered these questionnaires at inclusion, as patients with subacute fractures might not recall the before fracture condition.

**Pain was classified as “better” if the participant indicated that the pain was moderately or a great deal better than before the intervention and as “worse” if the pain was reported to be moderately or a great deal worse than before the intervention.

††Score on the Pain Frequency Index and Pain Bothersome Index range from 0 to 4, with higher score indicating more severe pain.

‡‡The prescribed analgesic use was classified into no medication (0), use of paracetamol (1), use of NSAIDs (2), and use of opiate derivatives (3).

Table 2: Results of RCTs comparing kyphoplasty versus other treatment.

Study (year)	Study characteristics	Functional outcomes	Pain	QoL	Safety
Wardlaw (2009) FREE trial	<p>Balloon kyphoplasty versus non-surgical care (analgesics, bed rest, back braces, physiotherapy, rehabilitation programs, walking aids, calcium and vitamin D supplements and antiresorptive or anabolic agents) for acute vertebral fractures caused primarily by osteoporosis (1% in each group with multiple myeloma/metastatic disease)</p> <p>Follow-up: 1 year</p>	<p>RDQ At 1 month, scores improved by 4.0 points (95% CI, 2.6–5.5; $P < .0001$) more in the BK group than the Control group</p> <p>At 1 year, scores improved by 2.6 points (95% CI, 1.0–4.1; $P = .001$) more in the BK group than the Control group</p>	<p>VAS (1-10) <i>Back pain score</i> decreased by 2.2 points (95% CI, 1.6–2.8; $P < .0001$) more at 1 week in the BK group versus Controls, and by 0.9 points (95% CI, 0.3–1.5; $P = .003$) after 1 year</p> <p><i>Fewer days of restricted activity per 2 weeks due to back pain</i> was reported at 1 month in the BK group versus controls (2.9 days; 95% CI, 1.3–4.6; $P = .0004$); difference in improvement no longer significant at 1 year (1.6 days; 95% CI, -0.1 to 3.3; $P = 0.68$)</p> <p>A mean of 2.5 fewer days (95% CI, 1.2–3.8; $P < .0001$) of <i>restricted activity per 2 weeks</i> was reported during the year for patients in the BK group than the control group</p>	<p>SF-36 (PCS) Improvement in mean score from baseline to 1 month was 5.2 points greater in the BK group vs Control group (95% CI, 2.9–7.4; $P < .001$)</p> <p><u>Mean difference in improvement between groups:</u> 3 months: 4.0 points (95% CI, 1.6–6.3; $P = .001$) 6 months: 3.2 points (95% CI, 0.9–5.6; $P = .006$) 1 year: 1.5 points (95% CI, -0.8 to 3.9; $P = .21$)</p> <p>During the year, the score improved by a mean of 3.5 points more in the BK group versus Controls (95% CI, 1.6–5.4; $P = .0004$)</p> <p>There was a significant interaction between treatment and follow-up time ($P = .0104$), suggesting that the treatment effect over the</p>	<p>New vertebral fractures BK, n = 12 (14%); requiring additional kyphoplasty, n = 9 (6%) within 3 months: n = 6 within 6 months: n = 3</p> <p>At 1 year, 38 of 155 (33%) patients in the BK group and 24 of 95 (25%) patients in the Control group had new or worsening radiographic vertebral fractures (7.7% difference, 95% CI, -4.5 to 20.0; $P = .220$)</p> <p>Cement extravasation 51 (27%) of 188 vertebra; all were asymptomatic; mostly endplate or discal</p> <p>Adverse events BK: n = 130 (87%) Control: n = 122 (81%) 1 patient in each group withdrew because of adverse event</p> <p>Serious adverse events* <i>Total</i> BK: n = 58† Control: n = 54†</p> <p><i>Anemia</i></p>

				<p>year was not uniform across follow-up because of an early improvement in the kyphoplasty group</p> <p>SF-36 subscales Averaged across 1 year, patients assigned to BK had greater improvements than controls for (difference between groups): <i>body pain</i>: 9.2 points (95% CI, 3.9–14.6; $P < .0008$) <i>role physical</i>: 12.5 points (95% CI, 4.8–20.2; $P = .002$) <i>vitality</i>: 5.2 points (95% CI, 0.2–10.1; $P < .039$) <i>social function</i>: 11.4 points (95% CI, 4.0–18.9; $P = .003$)</p> <p>EQ5D BK group showed greater improvements from <i>baseline to 1 month</i> (difference between groups 0.18 points, 95% CI 0.08–0.28; $P = .0003$) and from <i>baseline to 12 months</i> (0.12 points, 95% CI, 0.01–0.22; $P = .025$)</p>	<p>BK: n = 3 Control: n = 1</p> <p><i>Back pain</i> BK: n = 10 Control: n = 10</p> <p><i>Coronary heart disease</i> BK: n = 7 Control: n = 4</p> <p><i>Arrhythmia</i> BK: n = 2 Control: n = 2</p> <p><i>PE</i> BK: n = 3 Control: n = 0</p> <p><i>Stroke</i> BK: n = 1 Control: n = 1</p> <p><i>Hematoma</i> BK: n = 1§ Control: n = 0</p> <p><i>Other cardiovascular/vascular disorder</i> BK: n = 6 Control: n = 5</p> <p><i>Infection</i> BK: n = 3 (1 clostridium, sepsis, and UTI§ each) Control: n = 5 (1 clostridium, 2 sepsis, and 2 UTIs)</p>
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					<p><i>Neoplasm/cancer</i> BK: n = 6 Control: n = 6</p> <p><i>Nervous system disorder</i> BK: n = 3 Control: n = 2</p> <p><i>Psychiatric disorder</i> BK: n = 3 Control: n = 0</p> <p><i>Pneumonia</i> BK: n = 6 Control: n = 5</p> <p><i>Other respiratory disorder</i> BK: n = 5 Control: n = 1</p> <p><i>Death</i> BK: n = 9 cardiovascular, n = 5 pneumonia, n = 0 cancer, n = 2 other, n = 2 Control: n = 7 cardiovascular, n = 3 pneumonia, n = 1 cancer, n = 1 other, n = 2</p>

BK: balloon kyphoplasty; EQ5D: EuroQoL-5D; PE: pulmonary embolism; PMMA: polymethylmethacrylate; PV: percutaneous vertebroplasty; OVCF: osteoporotic vertebral compression fractures; RDQ: Roland Morris Disability Questionnaire; SF-36 (PCS): Short Form-36 Physical Component Score; UTI: urinary tract infection; VAS: visual analog scale.

*An adverse event was serious if it resulted in death, life-threatening injury, or permanent impairment, or if it required extended hospital stay or intervention to prevent impairment.

†Patients might have had multiple serious adverse events.

§Hematoma and UTI judged to be related to kyphoplasty procedure.

Table 3. Results of RCTs comparing vertebroplasty with kyphoplasty.

Study (year)	Study characteristics	Functional outcomes	Pain	Radiographic	Safety
Liu (2010)	<p>PV versus BK (both using PMMA as bone filler) for OVCFs at the thoraco-lumbar junction</p> <p>Follow-up: 6 months</p>	NR	<p>VAS (1-10)</p> <p><u>PV</u> <i>preop</i>: 7.9 ± 0.7 <i>3 days</i>: 2.3 ± 0.5 <i>P</i> < .001 <i>6 months</i>: 2.6 ± 0.6 <i>P</i> < .001</p> <p><u>BK</u> <i>preop</i>: 8.0 ± 0.8 <i>3 days</i>: 2.6 ± 0.6 <i>P</i> < .001 <i>6 months</i>: 2.6 ± 0.6 <i>P</i> < .001</p> <p>No statistical difference between groups was found at any follow-up period</p>	<p>Vertebral body height</p> <p><u>PV</u> <i>preop</i>: 1.01 ± 0.22 cm <i>postop</i>: 1.32 ± 0.26 <i>P</i> < .001</p> <p><u>BK</u> <i>preop</i>: 1.13 ± 0.34 cm <i>postop</i>: 2.04 ± 0.41 cm <i>P</i> < .001</p> <p>Postop increase significantly greater following BK vs. PV, <i>P</i> .001</p> <p>Kyphotic wedge angle</p> <p><u>PV</u> <i>preop</i>: 15.5° ± 4.2° <i>postop</i>: 12.2° ± 3.6° <i>P</i> < .001</p> <p><u>BK</u> <i>preop</i>: 17.0° ± 7.3° <i>postop</i>: 9.0° ± 5.7° <i>P</i> < .001</p> <p>Postop reduction significantly greater following BK vs. PV, <i>P</i> .001</p>	<p>Amount of PMMA injected PV: 4.9 ± 0.65 BK: 5.6 ± 0.62 <i>P</i> < .001</p> <p>Operative time (minutes) PV: 44.0 ± 4.4 BK: 46.2 ± 4.5 <i>P</i> = .02</p> <p>Adjacent segment fractures BK, n = 2 at T11, 41 days postop at L2, 50 days postop</p>

BK: balloon kyphoplasty; PMMA: polymethylmethacrylate; PV: percutaneous vertebroplasty; OVCF: osteoporotic vertebral compression fractures.

Table 4: Results of nonrandomized studies comparing vertebroplasty versus conservative treatment.

Study (year)	Study characteristics	Functional outcomes	Pain	QoL	Safety
Alvarez (2006)*	Prospective cohort Osteoporotic patients presenting with acute vertebral fractures treated with PV or conservative medical treatment (bed rest, orally administered pain medication, and bracing)	Oswestry <u>preop</u> PV: 34 CMT: 28 $P < .001$ <u>3 months</u> PV: 18 CMT: 23 $P = .001$ <u>6 months</u> PV: 18 CMT: 15 $P = .006$ <u>1 year</u> PV: 17 CMT: 11 $P < .001$	VAS (0-10) <u>preop</u> PV: 9 CMT: 7.5 $P < .001$ postop PV: 4 CMT: 7.5 $P < .001$ <u>3 months</u> PV: 3.5 CMT: 5.6 $P < .001$ <u>6 months</u> PV: 3.1 CMT: 4.5 $P = .033$ <u>1 year</u> PV: 3 CMT: 3.5 $P = NS$ Analgesic use Proportion of PV patients who received opioids decreased from 71% (preop) to 26% during follow-up, $P < .001$	SF-36 Preoperatively, the PV group was significantly worse in all categories except for general health and mental health Patient satisfaction <u>PV</u> satisfied/very satisfied, 91% dissatisfied, 0% repeat operation, 91% <u>CMT</u> satisfied/very satisfied, 78% (dissatisfied patients complained of persistent aching and unfulfilled expectations)	Complications (PV group) transitory paraparesis from a massive PMMA leakage into the canal which required surgical decompression, n = 1; transitory radicular neuritis, n = 5; rib fractures related to positioning, n = 2; cement extravasations, n = 90 levels (60%) cement in the peridural plexus, n = 62 (41%) vertebra New vertebral fractures <u>PV</u> : n = 31 (30%; 36 levels) adjacent to initially treated vertebra, n = 12 (39%) occurred within 3 months, n = 8/12 (67%; 2/8 received repeat PV) <u>CMT</u> : n = 3 (11%) adjacent to initially treated vertebra, n = 2 (67%) $P < .01$ for rate of new vertebral fractures between groups

			Patients treated by PV had a greater reduction in analgesic dosage than the patients treated conservatively at 3 months, requiring even less medication		
Diamond (2006)	Prospective cohort Osteoporotic patients presenting with acute vertebral fractures treated with PV or conservative medical treatment (oral alendronate 70 mg weekly or intravenous pamidronate 60 mg six times monthly, calcium 1200 mg daily, ergocalciferol 0.25 µg daily (if vitamin D deficient))	<p>Barthel Index <u>baseline</u> PV: 14 ± 4 CMT: 14 ± 4 <i>P</i> = NS</p> <p><u>24 hours</u> PV: 18 ± 3 (+29%)† CMT: 14 ± 5 (0%)† <i>P</i> = .0001</p> <p><u>6 weeks</u> PV: 19 ± 2 (+36%)† CMT: 18 ± 3 (+29%)† <i>P</i> = .02 for raw scores <i>P</i> = NS for % change</p> <p><u>6–12 months</u> PV: 19 ± 1 (+36%)† CMT: 19 ± 2 (+36%)† <i>P</i> = NS</p> <p><u>2 years</u> PV: 19 ± 2 (+36%)† CMT: 19 ± 2 (+36%)† <i>P</i> = NS</p> <p>In PV group, <i>P</i> < .0001 for measurements at all follow-up periods when</p>	<p>VAS (0-5) for pain associated with 5 activities: walking, climbing in and out of a chair, bathing, dressing, resting</p> <p><u>baseline</u> PV: 20 ± 4 CMT: 20 ± 5 <i>P</i> = NS</p> <p><u>24 hours</u> PV: 8 ± 4 (-60%)† CT: 19 ± 5 (-5%)† <i>P</i> = .0001</p> <p><u>6 weeks</u> PV: 5 ± 4 (-75%)† CMT: 7 ± 5 (-65%)† <i>P</i> = NS</p> <p><u>6–12 months</u> PV: 3 ± 4 (-85%)† CMT: 4 ± 5 (-80%)† <i>P</i> = NS</p> <p><u>2 years</u> PV: 2 ± 3 (-90%)† CMT: 3 ± 3 (-85%)†</p>	NR	<p>Complications (PV group) fractured transverse process, n = 2 hemorrhage into the psoas muscle, n = 1</p> <p>New vertebral fractures PV: n = 29 fractures in 21 (24%) patients CMT: n = 11 fractures in 9 (24%) patients HR for PV compared with CT, 1.13, 95% CI, 0.52–2.46; <i>P</i> = .76</p> <p><i>new fracture adjacent to initial fracture</i> PV: n = 9 (43%) CMT: 4 (44%) <i>P</i> = .52</p> <p>Mortality Total: n = 21 (17%) PV: n = 15 CMT: n = 6 HR for death in PV group versus CMT group, 1.07 (95% CI, 0.42–2.76; <i>P</i> = .89)</p> <p><i>Predictors of all-cause mortality</i> Age: HR = 1.09, 95% CI, 1.02–</p>

		<p>compared with measurements before PV</p> <p>In CMT group, $P < .0001$ for measurements at 6 weeks, 6–12 months, and 2 years when compared with measurements before starting CMT</p>	<p>$P = NS$</p> <p>In PV group, $P < .0001$ for measurements at all follow-up periods when compared with measurements before PV</p> <p>In CMT group, $P < .0001$ for measurements at 6 weeks, 6–12 months, and 2 years when compared with measurements before starting CMT</p>		<p>1.17; $P < .01$</p> <p>Corticosteroid therapy: HR = 4.72, 95% CI, 1.9–11.7, $P < .01$</p> <p>Hospital admission: HR = 5.96, 95% CI, 1.98–17.94, $P < .01$</p> <p><i>Fracture-related death</i> HR for PV patients versus CMT patients, 0.11, 95% CI, 0.01–0.96, $P = .05$</p> <p>Length of stay PV: mean 10.4 days CMT: mean 17.5 days $P = .01$ (95% CI, 11–24 days)</p>
Ehteshami Rad (2010)	<p>Retrospective cohort</p> <p>Acute or subacute vertebral compression fractures treated with PV or without PV (this group was further divided into those patients with acute versus subacute fractures)</p>	NR	NR	NR	<p>Overall incident fractures PV: n = 39 (14%) no PV/acute: n = 8 (7%) no PV/subacute: n = 7 (9%)</p> <p>HR for PV versus no PV/acute = 2.2, 95% CI, 0.9–6.5</p> <p>HR for PV versus no PV/subacute = 2.9, 95% CI, 1.2–8.4</p> <p>Time to incident fracture PV: 5.5 months no PV/acute: 10 months no PV/subacute: 9 months</p> <p>$P = .01$ for PV versus no PV/acute</p> <p>$P = .07$ for PV versus no</p>

					<p>PV/subacute</p> <p>Incident fractures in patient with and without focal point tenderness PV: HR = 1.51, 95% CI, 0.6–9.3)</p> <p>no PV/acute: HR = 0.49, 95% CI, 0.1–2.1</p> <p>no PV/subacute: HR = 0.58, 95% CI, 0.1–2.7</p>
Masala (2008)	<p>Retrospective cohort</p> <p>Single symptomatic acute amyelic OVCFs treated with PV or conservative medical therapy (oxycodone 50-200 mg twice daily, tramadol 50-200 mg twice daily, and with/without addition of gabapentin 300-800 mg three times daily for persistent pain; back brace; physical therapy)</p>	<p>Ambulation scale (1–5 points)</p> <p><u>preop</u> PV: 3.6 ± 0.87 (3–5) CMT: 3.6 ± 0.89 (2–5)</p> <p><u>1 week</u> PV: 1.2 ± 0.37 (1–2) CMT: 3.2 ± 0.81 (1–5)</p> <p><u>3 months</u> PV: 1.2 ± 0.46 (1–3) CMT: 2.7 ± 0.80 (1–4)</p> <p><u>1 year</u> PV: 1.4 ± 0.53 (1–3) CMT: 1.6 ± 0.62 (1–3)</p> <p>In both groups, differences were significant at all follow-up times compared with preop, <i>P</i> < .05</p>	<p>VAS (1-10)</p> <p><u>preop</u> PV: 8.7 ± 1.20 (6–10) CMT: 8.6 ± 0.87 (7–10)</p> <p><u>1 week</u> PV: 1.1 ± 1.53 (0–6) CMT: 7.9 ± 0.67 (7–9)</p> <p><u>3 months</u> PV: 0.9 ± 1.44 (0–5) CMT: 4.2 ± 1.27 (1–7)</p> <p><u>1 year</u> PV: 1.1 ± 1.79 (0–5) CMT: 1.8 ± 1.14 (0–5)</p> <p>In both groups, differences were significant at all follow-up times compared with preop, <i>P</i> < .05</p>	NR	<p>Complications (PV group) asymptomatic disk space leakage of PMMA cement, n = 9 (16%)</p> <p>New vertebral fracture <u>PV</u>: n = 3 fractures (2 lumbar, 1 thoracic) in 2 patients (3.7%) adjacent to initial treated level: n = 1 symptomatic: n = 2 fractures in 2 patients (3.7%); both occurred 3 months after treatment selection <u>CMT</u>: n = 5 fractures (3 lumbar, 2 thoracic) in 4 patients (4.7%) adjacent to initial treated level: n = 2 symptomatic: n = 3 fractures in 3 patients (3.5%); one occurred at 3 months and two at 6 months after treatment selection</p>

		<p>Significant differences between groups were seen at 1 week and 3 months ($P < .05$) but not at 1 year</p> <p>ADL scale <u>preop</u> PV: 3.9 ± 0.79 (2–5) CMT: 4.0 ± 0.75 (3–5)</p> <p><u>1 week</u> PV: 1.2 ± 0.46 (1–3) CMT: 3.7 ± 0.79 (2–5)</p> <p><u>3 months</u> PV: 1.4 ± 0.63 (1–3) CMT: 2.8 ± 0.78 (1–4)</p> <p><u>1 year</u> PV: 1.5 ± 0.66 (1–3) CMT: 1.7 ± 0.60 (1–3)</p> <p>In both groups, differences were significant at all follow-up times compared with preop, $P < .05$</p> <p>Significant differences between groups were seen at 1 week and 3 months ($P < .05$) but not at 1 year</p>	<p>Significant differences between groups were seen at 1 week and 3 months ($P < .05$) but not at 1 year</p>		<p>$P = NS$ for difference between the frequencies of new vertebral fractures between groups</p> <p>Mortality <u>PV</u>: $n = 1$ (1.7%); acute MI deemed unrelated to procedure/vertebral fracture</p> <p><u>CMT</u>: $n = 5$ (5.3%); related to the vertebral fracture in 3 patients (2 for PE caused by DVT due to prolonged immobilization and 1 for pneumonia complicating a respiratory insufficiency worsened by the fracture) and unrelated to the vertebral fracture in the other 2 patients (one MI and one stroke)</p> <p>Length of hospitalization (mean) <u>PV</u>: 2.5 ± 0.6 days <u>CMT</u>: 33.5 ± 6.1 days</p>
Nakano	Retrospective	Radiographic	VAS (cm)	NR	CPC leakage into spinal canal,

(2006)	<p>cohort</p> <p>Osteoporotic vertebral compression fractures treated with calcium phosphate cement (CPC)-based PV versus conservative medical treatment (analgesic medication, physical exercise regimens, standing and walking routines in a cast for 8 weeks, brace for an additional 6 weeks)</p>	<p>deformity index</p> <p><u>preop</u> PV: 1.69 ± 0.21 CMT: 1.82 ± 0.26</p> <p><u>6 months</u> PV: 1.74 ± 0.26 CMT: 1.60 ± 0.33</p> <p><u>1 year</u> PV: 1.74 ± 0.26 CMT: 1.58 ± 0.33</p> <p><u>mean recovery rate</u> PV: +3.7% CMT: -13.2% <i>P</i> < .0001</p> <p>kyphosis rate</p> <p><u>preop</u> PV: 68.2% ± 12.7% CMT: 73.5% ± 14.8%</p> <p><u>6 months</u> PV: 73% ± 12.6 CMT: 60.6% ± 20.1%</p> <p><u>1 year</u> PV: 72.9% ± 12.6% CMT: 58% ± 18.7%</p> <p><u>mean recovery rate</u> PV: +8.4% CMT: -21% <i>P</i> < .0001</p>	<p><u>preop</u> PV: 7.93 CMT: 7.47</p> <p><u>6 months</u> PV: 0.7 CMT: 2.57</p> <p><u>1 year</u> PV: 0.67 CMT: 1.97</p> <p><u>improvement rate</u> PV: 91.6% CMT: 73.6% <i>P</i> < .0001</p> <p><u>mean duration of required analgesics</u> PV: 8.3 days CMT: 62.2 days <i>P</i> = .0005</p>		<p>n = 6 (20%) and intervertebral disc space, n = 2 (7%)</p>
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CMT: conservative medical therapy; DVT: deep vein thrombosis; HR = hazard ratio; OVCF: osteoporotic vertebral compression fractures; MI: myocardial infarction; NR = not reported; NS = not statistically significant; PE: pulmonary embolism; PMMA: polymethylmethacrylate; PV: percutaneous vertebroplasty; QoL: quality of life; RR: Relative Risk; VAS: Visual Analog Scale.

*All raw scores for each outcome were estimated from figures provided in the original article. Only *P*-values were provided in the text.

†Percent change from baseline.

Table 5: Results of nonrandomized studies comparing kyphoplasty versus conservative treatment.

Study (year)	Study characteristics	Functional outcomes	Pain	Radiographic	Safety
Kasperk (2010)	Prospective cohort Patients with primary osteoporosis and painful OVCFs treated with KP versus conservative medical treatment (oral aminobiphosphonate [alendronate 10 mg or risedronate 5 mg daily], calcium 1000 mg daily, vitamin D3 1000 IU daily, pain medication, regular physiotherapy)	EVOS score (mean) baseline KP: 43.8 ± 2.5 CMT: 39.8 ± 4.6 <i>P</i> = .445 <u>1 year</u> KP: 54.6 ± 3.0 CMT: 44.3 ± 5.1 <i>P</i> = .105* <u>3 years</u> KP: 54.8 ± 3.2 CMT: 43.6 ± 5.1 <i>P</i> = .082* In the KP group only, scores at both 1 and 3 years were significantly different versus baseline, <i>P</i> < .0003 and .0008, respectively.	VAS (total, mean) baseline KP: 73.8 ± 2.0 CMT: 66.4 ± 4.2 <i>P</i> = .123 <u>1 year</u> KP: 55.6 ± 3.1 CMT: 65.7 ± 4.4 <i>P</i> = .008* <u>3 years</u> KP: 54.0 ± 3.5 CMT: 64.0 ± 4.6 <i>P</i> = .023* In the KP group only, scores at both 1 and 3 years were significantly different versus baseline, <i>P</i> < .0001 for both.	Vertebral body height† baseline KP: 59.2% ± 1.3% CMT: 60.9% ± 2.5% <i>P</i> = .553 <u>1 year</u> KP: 66.7% ± 1.1% CMT: 55.8% ± 2.6% <i>P</i> < .0001* <u>3 years</u> KP: 64.7% ± 1.0% CMT: 51.2% ± 2.8% <i>P</i> < .0001* In the KP group, scores at both 1 and 3 years were significantly different versus baseline, <i>P</i> < .0001 for both. In the CMT group, scores at both 1 and 3 years were significantly different versus baseline, <i>P</i> = .0004 and .0001, respectively Kyphosis angle baseline KP: 8.6° ± 0.8° CMT: 8.0° ± 0.9° <i>P</i> = .568	No neurological, embolic, or cardiovascular symptoms following KP Cement leakage asymptomatic: 9.7% Total new vertebral fractures (only pts with available radiographs after 3 years) KP: 21 in 14/34 (41%) patients CMT: n = 18 in 10/14 (71%) patients <i>P</i> = .034 RR = .577 NNT = 4 New fractures of adjacent vertebra (only pts with available radiographs after 3 years) KP: 7/72 (9.7%) CMT: 4/29 (13.8%) <i>P</i> = .591 Predictors of fracture risk in multivariate analysis Age: <i>P</i> = .507 Sex: <i>P</i> = .160 VAS (preop): <i>P</i> = .949 EVOS (preop): <i>P</i> = .777 Vertebral height: <i>P</i> = .212 Kyphosis angle: <i>P</i> = .771 Bone density: <i>P</i> = .886 Number of prefractured vertebral

				<p><u>1 year</u> KP: $7.8^{\circ} \pm 0.8^{\circ}$ CMT: $10.4^{\circ} \pm 0.9^{\circ}$ $P = .0001^*$</p> <p><u>3 years</u> KP: $7.7^{\circ} \pm 0.8^{\circ}$ CMT: $11.1^{\circ} \pm 1.1^{\circ}$ $P < .0001^*$</p> <p>In the KP group, scores at the 3-year follow-up only were significantly different versus baseline, $P < .010$.</p> <p>In the CMT group, scores at both 1 and 3 years were significantly different versus baseline, $P = .0004$ and $.002$, respectively</p>	<p>bodies: $P = .542$ Number of treated fractured vertebral bodies: $P = .773$ Kyphoplasty performed: $P = .064$</p>
Kasperk (2008)	<p>Prospective cohort</p> <p>Patients with primary osteoporosis and painful OVCFs treated with KP versus conservative medical treatment (oral aminobiphosphonate [alendronate 10 mg or risedronate 5 mg daily], calcium 1000</p>	<p>EVOS score (mean)</p> <p><u>baseline</u> KP: 43.8 ± 2.4 CMT: 39.8 ± 4.5</p> <p><u>3 months</u> KP: 52.7 ± 2.6 CMT: 45.1 ± 5.3</p> <p>baseline value adjusted: 6.3, 95% CI, -2.1–14.6; $P = .139$</p> <p>covariate adjusted‡:</p>	<p>VAS (total, mean)</p> <p><u>baseline</u> KP: 26.2 ± 2.0 CMT: 33.6 ± 4.1</p> <p><u>3 months</u> KP: 42.4 ± 2.9 CMT: 33.9 ± 4.6</p> <p>baseline value adjusted: 13.8, 95% CI, 3.9–23.8; $P = .007$</p> <p>covariate adjusted‡:</p>	<p>Kyphosis angle (means and group differences)</p> <p><u>baseline</u> KP: $8.7^{\circ} \pm 0.8^{\circ}$ CMT: $7.1^{\circ} \pm 1.2^{\circ}$</p> <p><u>3 months</u> KP: $8.6^{\circ} \pm 1.1^{\circ}$ CMT: $8.4^{\circ} \pm 1.1^{\circ}$</p> <p>baseline value adjusted: -2.1°, 95% CI, -4.0° to -2.0°; $P = .031$</p>	<p>New vertebral fractures KP: n = 6 fractures in 5 patients (12.5%) CMT: 8 fractures in 6 patients (30%) $\chi^2 = 1.46$, $P = .227$</p> <p>Adjacent vertebral fractures KP: n = 5/84 (6%) CMT: n = 5/41 (12%) $P = .323$</p> <p>Cement leakage n = 7/72 vertebra (9.7%)</p>

	<p>mg daily, vitamin D3 1000 IU daily, pain medication, regular physiotherapy)</p>	<p>5.4, 95% CI, -3.1–14.0; $P = .205$</p> <p><u>6 months</u> KP: 54.4 ± 2.7 CMT: 43.8 ± 4.6</p> <p>baseline value adjusted: 7.4, 95% CI, 0.5–14.5; $P = .031$</p> <p>covariate adjusted‡: 7.7, 95% CI, 0.7–14.6; $P = .031$</p>	<p>13.2, 95% CI, 3.3–23.4; $P = .012$</p> <p><u>6 months</u> KP: 44.2 ± 3.3 CMT: 35.6 ± 4.1</p> <p>baseline value adjusted: 13.4, 95% CI, 3.5–23.6; $P = .007$</p> <p>covariate adjusted‡: 13.8, 95% CI, 3.9–23.8; $P = .007$</p> <p>Use of opiates KP: reduced from 67.5% preop to 55% CMT: reduced from 70% to 65%</p> <p>Back pain-related doctor visits in the 6 months of follow-up KP: 3 ± 3 visits CMT: 8 ± 6 visits $P = .015$</p>	<p>covariate adjusted‡: -2.1°, 95% CI, -4.1° to -0.1°; $P = .038$</p> <p><u>6 months</u> KP: $8.3^\circ \pm 0.9^\circ$ CMT: $12.0^\circ \pm 1.1^\circ$</p> <p>baseline value adjusted: -4.8°, 95% CI, -6.9° to -2.8°; $P < .0001$</p> <p>covariate adjusted‡: -5.0°, 95% CI, -7.0° to -2.9°; $P < .0001$</p> <p>Vertebral body height† <u>baseline</u> KP: $53.3\% \pm 1.7\%$ CMT: $63.3\% \pm 2.2\%$</p> <p><u>3 months</u> KP: $66.3\% \pm 1.2\%$ CMT: $61.5\% \pm 2.3\%$</p> <p>baseline value adjusted: 7.5%, 95% CI, 4.8%–10.1%; $P < .0001$</p> <p>covariate adjusted‡: 7.9%, 95% CI, 5.1%–10.6%; $P < .0001$</p> <p><u>6 months</u> KP: $65.3\% \pm 1.2\%$ CMT: $58.0\% \pm 2.2\%$</p>	<p>No neurological, embolic, or cardiovascular symptoms following KP</p>
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				<p>baseline value adjusted: 9.8%, 95% CI, 7.2%– 12.4%; <i>P</i> < .0001</p> <p>covariate adjusted‡: 10.1%, 95% CI, 7.5%– 12.7%; <i>P</i> < .0001</p> <p>Percent change in vertebral body height <u>3 months</u> KP: 14.1% ± 2.6% CMT: -2.6% ± 0.6%</p> <p>non-baseline value adjusted: 16.7%, 95% CI, 9.5%–23.8%; <i>P</i> < .0001</p> <p>covariate adjusted‡: 17.8%, 95% CI, 10.3%–25.3%; <i>P</i> < .0001</p> <p><u>6 months</u> KP: 12.1% ± 2.3% CMT: -8.2% ± 1.3%</p> <p>non-baseline value adjusted: 20.3%, 95% CI, 13.4%–27.2%; <i>P</i> < .0001</p> <p>covariate adjusted‡: 10.1%, 95% CI, 7.5%– 12.7%; <i>P</i> < .0001</p>	
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<p>An (2008)</p>	<p>Retrospective cohort</p> <p>Patients with osteoporotic burst fractures treated with percutaneous KP versus either conservative medical treatment or posterior instrumentation and fusion (2 control groups)</p>	<p>Chen and Lee's semiquantitative scale (mobility)</p> <p><u>baseline</u> grade 3 or 4 in all patients</p> <p><u>1 year</u> <i>improvement to grade 0</i> KP: n = 12 (100%) CMT: n = 12 (36.5%) posterior surgery: n = 13 (100%)</p> <p><i>improvement to grade 1</i> CMT: n = 18 (54.5%)</p> <p><i>improvement to grade 2</i> CMT: n = 3 (9%)</p>	<p>VAS (0-10)</p> <p><u>baseline</u> KP: 8.3 ± 0.4 CMT: 7.9 ± 0.4 posterior surgery: 8.5 ± 0.5</p> <p><u>3 days postop</u> KP: 3.9 ± 0.2 posterior surgery: 3.5 ± 0.2</p> <p><u>3 months</u> KP: 3.2 ± 0.2 CMT: 4.8 ± 0.2 posterior surgery: 3.4 ± 0.2</p> <p><u>1 year</u> KP: 3.1 ± 0.2 CMT: 4.5 ± 0.2 posterior surgery: 3.2 ± 0.2</p> <p>$P = .012$ for difference in mean improvement between KP group (5.2 ± 0.3) and CMT group (3.4 ± 0.2)</p> <p>$P = .125$ for difference in mean improvement between KP group (5.2 ± 0.3) and posterior surgery group (5.3 ± 0.3)</p>	<p>Kyphotic deformity angle</p> <p><u>baseline</u> KP: $15.9^\circ \pm 2.4^\circ$ CMT: $5.2^\circ \pm 1.4^\circ$ posterior surgery: $19.1^\circ \pm 2.4^\circ$</p> <p><u>postop</u> KP: $6.2^\circ \pm 1.6^\circ$ posterior surgery: $9.1^\circ \pm 1.8^\circ$</p> <p><u>1 year</u> KP: $5.9^\circ \pm 1.4^\circ$ CMT: $14.8^\circ \pm 2.1^\circ$ posterior surgery: $8.9^\circ \pm 1.7^\circ$</p> <p>$P = .016$ for difference in mean improvement between the KP ($9.7^\circ \pm 2.2^\circ$) and CMT ($-9.6^\circ \pm 0.7$) groups</p> <p>$P = .081$ for difference in mean improvement between the KP ($10^\circ \pm 1.0^\circ$) and posterior surgery groups ($10.2^\circ \pm 0.7^\circ$)</p>	<p>cement leakage into the intervertebral disc without neurological symptoms, n = 1</p>
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Ming (2007)	VCFs compressed by 50%-70%	NR	<p>VAS (0-10) <u>preoperative</u> KP: 8.8 ± 0.5 PS: 8.6 ± 0.9</p> <p><u>postoperative</u> KP: 2.7 ± 0.9 PS: 8.2 ± 1.0</p> <p><i>P</i> < .01 for difference in pre- versus postoperative scores in the KP group and for between group differences</p> <p>92% of patients in the KP groups could ambulate by the first day after operation</p>	<p>Mean vertebral height <u>preoperative</u> KP: 18.3 ± 2.0 PS: 18.4 ± 1.8</p> <p><u>postoperative</u> KP: 23.3 ± 1.8 PS: 23.4 ± 2.1 <i>P</i> = NS</p>	<p>Operative time (mins) KP: 43.0 ± 6.0 PS: 215 ± 60 <i>P</i> < .01</p> <p>Blood loss KP: 22.0 ± 5.0 PS: 450 ± 125 <i>P</i> < .01</p> <p>Cement leakage anterior border, n = 2 (7%) spinal canal, n = 0</p> <p>Loose pedicle screw, n = 3 (5%)</p> <p>Internal fixation breakage, n = 4 (7%) (one 3 months post-surgery and one 6-12 months post-surgery)</p>
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CMT: conservative medical therapy; DVT: deep vein thrombosis; EVOS: European Vertebral Osteoporosis Study; HR = hazard ratio; KP: kyphoplasty; OVCF: osteoporotic vertebral compression fractures; MI: myocardial infarction; NR = not reported; NS = not statistically significant; PE: pulmonary embolism; PMMA: polymethylmethacrylate; PS: pedicle screw; PV: percutaneous vertebroplasty; QoL: quality of life; RR: Relative Risk; VAS: Visual Analog Scale.

*Analysis of covariance adjusted for baseline value.

†Percent of posterior wall of closest nonfractured vertebral body.

‡Adjusted for age, sex, and number of preoperative fractures.

Table 6: Results of nonrandomized studies comparing vertebroplasty with kyphoplasty

Study (year)	Study characteristics	Functional outcomes	Pain	Radiographic	Safety
Santiago (2010)	Prospective cohort Patients with non-traumatic or low-energy vertebral fractures and a diagnosis of primary osteoporosis treated with either PV or KP	Global ODI preoperative PV: 32.2 KP: 30.8 1 month PV: 15.0 KP: 11.3 6 months PV: 15.0 KP: 12.1 1 year PV: 15.3 KP: 12.1 For both groups, $P < .05$ for difference between preoperative score and scores at all follow-up time points. $P = NS$ for between group difference (Individual ODI items scores also listed but not abstracted here)	VAS preoperative PV: 8.6 KP: 8.6 1 month PV: 4.4 KP: 3.5 6 months PV: 4.5 KP: 3.5 1 year PV: 4.6 KP: 3.7 For both groups, $P < .05$ for difference between preoperative score and scores at all follow-up time points. $P = NS$ for between group difference	Anterior vertebral height (mm) preoperative PV: 15.9 ± 0.8 KP: 15.8 ± 0.8 postoperative PV: 16.1 ± 0.8 KP: 18.0 ± 0.9 Mid vertebral height (MM) preoperative PV: 17.1 ± 0.7 KP: 16.5 ± 0.9 postoperative PV: 17.4 ± 0.8 KP: 18.8 ± 0.9 $P = NS$ for between group difference for both height measurements	Cement leakage into disc PV: n = 6 KP: n = 7 $P = NS$ Cement leakage into paravertebral soft tissue (including veins) PV: n = 8 KP: n = 2 $P = NR$
Röllinghoff (2009)	Prospective cohort Patients with OVCFs treated with PV or KP	ODI preoperative PV: 67.6 ± 19.8 KP: 69 ± 18.4	VAS preoperative PV: 8.8 ± 1.2 KP: 8.6 ± 1.9	Mean vertebral height restoration (mm) preoperative PV: 14.1 ± 5.1 KP: 14.7 ± 5.6	Cement leakage without neurological symptoms Total PV: n = 13/51 (25.5%) KP: n = 12/53 (22.6%)

		<p><u>postoperative</u> PV: 36.4 ± 12.4 KP: 34.2 ± 11.3</p> <p><i>P</i> < .05 for difference between preoperative and postoperative scores in both groups</p> <p><i>P</i> = NS for PV vs. KP</p> <p><u>1 year</u> PV: 24 ± 15.1 KP: 24.1 ± 19.6</p> <p><i>P</i> < .001 for difference between preoperative and 1 year scores in both groups</p> <p><i>P</i> = NS for PV vs. KP</p>	<p><u>postoperative</u> PV: 4.8 ± 2.5 KP: 3.4 ± 2.3</p> <p><i>P</i> < .05 for difference between preoperative and postoperative scores in both groups</p> <p><i>P</i> = NS for PV vs. KP</p> <p><u>1 year</u> PV: 2.5 ± 2.1 KP: 2.5 ± 2.6</p> <p><i>P</i> < .001 for difference between preoperative and 1 year scores in both groups</p> <p><i>P</i> = NS for PV vs. KP</p>	<p><u>postoperative</u> PV: 17.9 ± 4.2 KP: 19.5 ± 4.5</p> <p><i>P</i> < .05 for difference between preoperative and postoperative scores in both groups</p> <p><u>1 year</u> PV: 16.5 ± 5.5 KP: 18.8 ± 4.6</p> <p><i>P</i> < .05 for difference between preoperative and postoperative scores in KP group only</p> <p>Kyphosis angle <u>preoperative</u> PV: 10.8° ± 7.8° KP: 9.9° ± 5.7°</p> <p><u>postoperative</u> PV: 8.0° ± 4.8° KP: 8.9° ± 6.1°</p> <p><u>1 year</u> PV: 9.2° ± 5.3° KP: 9.8° ± 6.2°</p> <p><i>P</i> = NS for all comparisons</p>	<p><u>into spinal canal</u> PV: n = 3 (5.9%) KP: n = 1 (1.9%)</p> <p><u>into intervertebral disc</u> PV: n = 6 (11.8%) KP: n = 5 (9.4%)</p> <p><u>into vessel</u> PV: n = 0 (0%) KP: n = 2 (3.8%)</p> <p><u>lateral of vertebral body</u> PV: n = 3 (5.9%) KP: n = 2 (3.8%)</p> <p><u>ventral of vertebral body</u> PV: n = 1 (2.0%) KP: n = 2 (3.8%)</p> <p>Cement leakage into spinal canal with neurological symptoms PV: n = 2 (4.0%) KP: n = 0 (0%)</p> <p>Adjacent segment fracture PV: n = 4 (7.8%) KP: n = 7 (13.2%)</p> <p><i>with surgery</i> PV: n = 4 (7.8%) KP: n = 4 (7.5%)</p> <p>Dorsal spondylolysis and decompression</p>
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				<p>Anterior edge (mm) <u>preoperative</u> PV: 22.5 ± 6.7 KP: 22.8 ± 7.4</p> <p><u>postoperative</u> PV: 24.4 ± 5.7 KP: 24.9 ± 6.2</p> <p><u>1 year</u> PV: 23.0 ± 6.1 KP: 24.3 ± 6.2</p> <p><i>P</i> = NS for all comparisons</p> <p>Posterior edge (mm) <u>preoperative</u> PV: 28.9 ± 4.9 KP: 29.7 ± 5.0</p> <p><u>postoperative</u> PV: 29.8 ± 4.9 KP: 31.0 ± 5.4</p> <p><u>1 year</u> PV: 29.2 ± 4.8 KP: 30.4 ± 5.7</p> <p><i>P</i> = NS for all comparisons</p>	<p>PV: n = 1 (2%) KP: n = 0 (0%)</p> <p>Decompression PV: n = 1 (2%) KP: n = 0 (0%)</p>
Schofer (2009)	Prospective cohort Patients with fresh thoracic or lumbar single-segment OVCFs not	SF-36 at 1 year No significant difference were found either between the PV or KP groups or between the patients	VAS (0-10) <u>preoperative</u> PV: 8.3 ± 2.6 KP: 8.2 ± 2.3 <u>postoperative</u>	Kyphosis angle <u>preoperative</u> PV: 11.4° ± 3.4° KP: 12.5° ± 2.8° <u>postoperative</u>	Balloon rupture (KP group) n = 1 Cement leakage <i>Total</i> PV: n = 10 (33%)

	involving neurological deficits treated by PV or KP	and an age- and sex-matched reference group (no global scores given)	<p>PV: 3.0 ± 1.6 KP: 3.2 ± 1.2</p> <p><u>1 year</u> PV: 2.8 ± 1.8 KP: 2.6 ± 1.3</p> <p>For both groups, $P < .001$ for difference between preoperative scores and scores at both follow-up time points.</p> <p>$P = \text{NS}$ for between group differences</p>	<p>PV: $9.4^\circ \pm 1.0^\circ$ KP: $6.6^\circ \pm 2.4^\circ$</p> <p><i>improvement from preoperative</i> PV: $2.0^\circ \pm 2.4^\circ$ KP: $5.9^\circ \pm 2.7^\circ$ $P < .001$ for both groups</p> <p><u>1 year</u> PV: $10.4^\circ \pm 1.4^\circ$ KP: $7.1^\circ \pm 2.7^\circ$</p> <p><i>improvement from preoperative</i> PV: $1.0^\circ \pm 2.0^\circ$ $P < .002$ KP: $5.4^\circ \pm 2.9^\circ$ $P < .001$</p> <p>Improvement in kyphosis angle at both follow-ups was significantly more pronounced in the KP group, 95% CI, 3–5; $P < .001$ and 95% CI 3–6; $P < .001$, respectively</p>	<p>KP: $n = 2$ (7%) $P = .021$, 95% CI for OR 0.014–0.800</p> <p><i>into basivertebral vein</i> PV: $n = 3$ KP: $n = 0$</p> <p><i>into segmental vein</i> PV: $n = 6$ KP: $n = 1$</p> <p><i>into cortical defect</i> PV: $n = 5$ KP: $n = 1$</p> <p>Adjacent-level fracture PV: $n = 1$ KP: $n = 0$</p>
Zhou (2008)	Prospective cohort Patients with VCFs treated by PV or KP	NR	<p>VAS (1-10) <u>preoperative</u> PV: 8.4 ± 0.5 KP: 8.5 ± 0.8</p> <p><u>postoperative</u> PV: 2.7 ± 1.0 KP: 2.6 ± 1.0</p> <p>$P < .01$ for difference</p>	<p>Mean vertebral height (mm) <u>preoperative</u> PV: 18.6 ± 2.2 KP: 18.1 ± 1.8</p> <p><u>postoperative</u> PV: 19.4 ± 1.8 KP: 23.5 ± 2.0</p>	<p>Cement leakage <i>into anterior border</i> PV: $n = 5$ KP: $n = 3$</p> <p><i>into spinal canal</i> PV: $n = 1$ KP: $n = 0$</p> <p>Operation time (min)</p>

			<p>between pre- and postoperative scores in both groups</p> <p>$P = NS$ for between group difference</p>	<p>$P < .01$ for difference between pre- and postoperative scores in the KP group only and between postoperative PV and KP scores.</p>	<p>PV: 38 ± 8.0 KP: 45 ± 6.0</p> <p>Blood loss (ml) PV: 23 ± 5.0 KP: 25 ± 5.0</p>
De Negri (2007)	<p>Prospective cohort</p> <p>Patients with painful vertebral compression fractures resistant to common therapies treated with either PV or KP</p>	<p>ODI</p> <p><u>preoperative</u> PV: 37.4 ± 5.2 (74% disability) KP: 38.5 ± 4.4 (77% disability)</p> <p><u>postoperative</u> PV: 12.6 ± 1.6 (24% disability) KP: 12.1 ± 1.6 (23% disability)</p> <p>For both treatments, $P < .05$ for difference between preoperative and postoperative scores</p> <p>$P = NS$ for PV vs. KP</p>	<p>VAS</p> <p><u>preoperative</u> PV: 8.3 ± 1.21 KP: 8.3 ± 1.25</p> <p><u>postoperative (1 hour)*</u> PV: 1.1 KP: 1.5</p> <p><u>2 days*</u> PV: 0.8 KP: 0.9</p> <p><u>1 month*</u> PV: 1.7 KP: 1.0</p> <p><u>3 months*</u> PV: 1.0 KP: 0.6</p> <p><u>6 months</u> PV: 0.55 ± 0.52 KP: 0.70 ± 0.67</p> <p>$P < .05$ for difference between preoperative vs. 6 month scores for both treatments</p>	NR	<p>Cement leakages without neurological symptoms PV: n = 5 KP: n = 0</p>

			<i>P</i> = NS for PV vs. KP at all time points		
Grohs (2005)	Prospective cohort Patients with symptomatic OVCFs of the lumbar or thoracic spine of type A in the classification of Magerl et al	<p>ODI (0%–100%) <u>preoperative</u> PV: 49% (35%–62%) KP: 61% (48%–69%)</p> <p><u>4 months</u> PV: 46% KP: 38%</p> <p><u>1 year</u> PV: 47% (31%–56%) <i>P</i> = NS vs. preoperative score KP: 42% (25%–52%) <i>P</i> = .03 vs. preoperative score</p> <p><u>2 years</u> PV: 52% (32%–67%) <i>P</i> = NS vs. preoperative score KP: 56% (44%–70%) <i>P</i> = NS vs. preoperative score</p> <p><i>P</i> < .05 for difference between 4 month and 1 year scores compared with preoperative scores in the KP group only</p>	<p>VAS (0-10) <u>preoperative</u> PV: 7.8 (5.5–9.4) KP: 7.4 (5.9–8.2)</p> <p><u>postoperative (day 1)</u> PV: 3.0 (2.0–4.0) <i>P</i> = .002 vs. preoperative score KP: 3.5 (2.5–5.9) <i>P</i> = .00003 vs. preoperative score</p> <p><u>4 months</u> PV: 5.7 KP: 3.2</p> <p><u>1 year</u> PV: 5.7 (3.8–6.6) <i>P</i> = .04 vs. preoperative score KP: 2.7 (1.6–3.8) <i>P</i> = .0004 vs. preoperative score</p> <p><u>2 years</u> PV: 4.6 (0.6–6.3) <i>P</i> = .03 vs. preoperative score KP: 2.0 (0.5–5.3) <i>P</i> = .005 vs. preoperative score</p> <p>For both PV and KP, <i>P</i> < .05 for differences</p>	<p>Kyphotic wedge angle <u>preoperative</u> PV: 12° (10°–17°) KP: 13° (10°–16°)</p> <p><u>decrease in wedge postoperatively</u> PV: 0° (0°–0.3°) KP: 6° (0°–9.5°)</p> <p><i>P</i> = .000004 for difference vs. preoperative score in KP group only</p> <p>Reduced of wedge > 5° was associated with a more pronounced decrease in pain (subgroup analysis of 15 (54%) KP patients)</p> <p>Vertebral body height <u>preoperative</u> PV: 83% (74%–88%) KP: 80% (74%–85%)</p> <p><u>increase of height postoperatively</u> PV: 0% KP: 5.8% (0%–10.6%)</p> <p><i>P</i> = .00001 for difference vs. preoperative score in KP group only</p>	<p>Adjacent level fractures (within first 4 months) PV: n = 1 KP: n = 6</p> <p>Cement leakage: <i>into disc space</i> PV: n = 4 KP: n = 8</p> <p><i>into epidural space</i> PV: n = 2 KP: n = 0</p> <p><i>into segmental vessels</i> PV: n = 2 KP: n = 0</p> <p>For PV group, leakage into epidural space and segmental vessels gives a rate of 25% leakage into critical areas.</p>

			in scores at all time points compared to preoperative score		
Hiwatashi (2009)	<p>Retrospective cohort</p> <p>Patients with painful OVCFs unresponsive to conservative treatment in a pain or orthopedic clinic treated with either PV or KP</p>	NR	NR	<p>Mean vertebral body height (mm)</p> <p><i>Anterior portion</i></p> <p><u>preoperative</u> PV: 19.7 KP: 20.4</p> <p><u>postoperative</u> PV: 21.5 KP: 22.5</p> <p><u>restoration</u> PV: 1.8 KP: 2.2</p> <p><i>Central portion</i></p> <p><u>preoperative</u> PV: 14.3 KP: 14.1</p> <p><u>postoperative</u> PV: 16.2 KP: 15.8</p> <p><u>restoration</u> PV: 1.8 KP: 1.7</p> <p><i>Posterior portion</i></p> <p><u>preoperative</u> PV: 24.0 KP: 25.1</p> <p><u>postoperative</u></p>	<p>Cement leakage:</p> <p><i>into disc space</i> PV: 25.0% (62/248) KP: 12/3% (14/114) <i>P</i> < .01</p> <p><i>into paravertebral soft tissues/veins</i> PV: 49.2% (61/124) KP: 17.5% (10/57) <i>P</i> < .01</p> <p>No complications related to cement leakage were noted</p>

				<p>PV: 24.4 KP: 25.5</p> <p><u>restoration</u> PV: 0.5 KP: 0.5</p> <p>For both groups, $P < .05$ for improvement in vertebral body height in anterior, central and posterior portions</p> <p>Mean wedge angle <u>preoperative</u> PV: 7.8° KP: 7.8°</p> <p><u>postoperative</u> PV: 5.1° KP: 4.7°</p> <p><u>restoration</u> PV: 2.7° KP: 3.0°</p> <p>For both groups, $P < .05$ for improvement in wedge angle</p> <p>$P = NS$ for between groups difference</p>	
Frankel (2007)	Retrospective cohort Patients with	NR	VAS (0-10) <u>postoperative</u> PV: 1.3 ± 0.6	NR	Mean cement injected per vertebral body PV: 3.78 ± 1.3 KP: 4.65 ± 0.9

	OVCFs treated using PV or KP		<p>KP: 1.6 ± 0.8 P = .3</p> <p>Comparative pain score* <u>complete relief (score 1)</u> PV: 74% (14/19) KP: 53% (9/17)</p> <p><u>improvement (scores 1 and 2 combined)</u> PV: 95% (18/19) KP: 94% (16/17)</p> <p><u>no improvement (scores 3 and 4 combined)</u> PV: 5% (1/19) KP: 6% (1/17)</p>		<p>P = .01</p> <p>Asymptomatic cement leakage Total: 11% (5/46) PV: 15% (3/20) KP: 7.7% (2/26) P = .7</p> <p><i>into the external venous plexus</i> PV: n = 1 KP: n = 1</p> <p><i>into the posterior vertebral elements</i> PV: n = 1 KP: n = 0</p> <p><i>into disc space</i> PV: n = 1 KP: n = 1</p> <p>Adjacent-level fractures (all were symptomatic and occurred within 3 months of procedure) PV: n = 0 KP: n = 5 (25%) in 3 patients P < .05</p>
Muto (2008)	<p>Retrospective cohort (??)</p> <p>Patients with osteoporosis† treated with PV and patients with Magerl type A1 and A3 fractures treated by KP within 3 month</p>	<p>Clinical success (based on evaluations with the VAS and ODI at 3 and 6 months) <u>PV</u>: 90% <u>KP</u>: type A1 fractures, 95% type A3 fractures, 90%</p>	NR	NR	<p>Cement leakage into vascular system or intervertebral disc PV: unable to determine osteoporosis pts only KP: NR</p> <p>New vertebral fractures PV: n = 19 KP: NR</p> <p>New adjacent vertebral</p>

	from trauma				fractures PV: n = 25 KP: NR
Köse (2006)	Retrospective cohort Patients with multiple myeloma and symptomatic compression fractures unresponsive to conservative treatment treated by either PV or KP.	NR	<p>Overall VAS score (composite, 0-50)‡ <u>preoperative</u> PV: 37.8 ± 3.3 KP: 36 ± 4.5</p> <p><u>6 weeks</u> PV: 15.3 ± 4.1 KP: 12.1 ± 3.6</p> <p><u>6 months</u> PV: 12.2 ± 3.0 KP: 8.6 ± 2.3</p> <p><u>1 year</u> PV: 13.5 ± 2.9 KP: 9.7 ± 2.4</p> <p>In both groups, $P < .001$ for difference in preoperative scores versus scores at all follow-up times</p> <p>Mean decrease in VAS scores <u>6 weeks</u> PV: 59.9% KP: 66.8% $P = NS$</p> <p><u>6 months</u> PV: 68.1%</p>	NR	<p>No adjacent level fractures, intraoperative or postoperative neurologic or pulmonary complications in either group</p> <p>Balloon rupture in one KP patient; procedure was successfully completed.</p>

			<p>KP: 76.1% <i>P</i> = .024</p> <p><u>1 year</u> PV: 64.4% KP: 73% <i>P</i> = .027</p> <p>Analgesic usage (times per week) in PV + KP groups</p> <p><u>preoperative</u> 9 (5–14)</p> <p><u>6 weeks</u> 5 (2–9) <i>P</i> = .031 vs. preop</p> <p><u>6 months</u> 2 (0–5) <i>P</i> = .012 vs. preop</p> <p><u>1 year</u> 3 (0–7) <i>P</i> = .023 vs. preop</p> <p>Need for analgesics was significantly decreased in both groups.</p>		
Lovi (2009)	Prospective cohort	<p>ODI (mean) preoperative PV: 52.3 KP: 49.1</p> <p><u>1 month</u> PV: 23 KP: 22.1</p>	<p>VAS, 0-10 (mean) preoperative PV: 8.4 KP: 8</p> <p><u>1 month</u> PV: 3.6 KP: 3.4</p>	<p>Anterior vertebral body collapse (%)</p> <p><u>preoperative</u> PV: 21± 2 KP: 39 ± 3</p> <p><u>postoperative</u> PV: 21± 1</p>	<p>Cement leakage outside the vertebral body: 14.6% (29/199 vertebra)</p> <p><u>Adjacent disc</u>, 14 levels PV: 10 levels KP: 4 levels <i>P</i> < .05</p> <p><u>Perivertebral veins</u>, 9 levels</p>

		<p>$P < .05$ compared to preop scores</p> <p><u>3 months</u> PV: 12.7 KP: 13.1</p> <p>$P < .05$ compared to preop and 1 month scores</p> <p><u>6 months</u> PV: 8.5 KP: 7.2</p> <p><u>2 years</u> PV: 6.7 KP: 4.8</p> <p>ODI score improved nonsignificantly in both groups after 3 months</p> <p>No significant differences between groups were reported at any time point</p>	<p>$P < .05$ compared to preop scores</p> <p><u>3 months</u> PV: 3.2 KP: 3</p> <p><u>6 months</u> PV: 3 KP: 2.6</p> <p><u>2 years</u> PV: 2 KP: 1.9</p> <p>VAS score decreased nonsignificantly in both groups after 1 month</p> <p>No significant differences between groups were reported at any time point</p> <p>Complete pain relief PV: 18.6% (22/118) KP: 16.6% (6/36) $P = ns$</p>	<p>KP: 32 ± 2</p> <p><u>3 months</u> PV: 20 ± 3 KP: 33 ± 3</p> <p><u>6 months</u> PV: 20 ± 3 KP: 33 ± 2</p> <p><u>2 years</u> PV: 21 ± 3 KP: 34 ± 3</p> <p>Midline vertebral body collapse (%) <u>preoperative</u> PV: 19 ± 1 KP: 37 ± 4</p> <p><u>postoperative</u> PV: 20 ± 2 KP: 30 ± 3</p> <p><u>3 months</u> PV: 20 ± 2 KP: 30 ± 3</p> <p><u>6 months</u> PV: 19 ± 1 KP: 31 ± 2</p> <p><u>2 years</u> PV: 19 ± 2 KP: 31 ± 3</p> <p>Posterior vertebral</p>	<p>PV: 7 levels KP: 2 levels $P < .05$</p> <p><u>Epidural space</u>, 1 level PV: 1 level KP: 0 levels</p> <p>Subsequent vertebral fracture PV: $n = 4$ (2 adjacent fractures) at a mean 9 months postop KP: $n = 0$</p> <p>Mortality PV: $n = 1$ (preexisting COPD) KP: $n = 0$</p>
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				<p>body collapse (%)</p> <p><u>preoperative</u> PV: 9 ± 2 KP: 12 ± 2</p> <p><u>postoperative</u> PV: 10 ± 2 KP: 10 ± 2</p> <p><u>3 months</u> PV: 10 ± 2 KP: 10 ± 2</p> <p><u>6 months</u> PV: 9 ± 1 KP: 11 ± 2</p> <p><u>2 years</u> PV: 9 ± 1 KP: 11 ± 1</p>	
Lee (2010)	Retrospective cohort	NR	NR	NR	<p>Local leakage of bone cement</p> <p><i>KP</i>, 49% (29/59 cases) perivertebral vein, n = 7; perivertebral soft tissue, n = 6; epidural space, n = 4; discal space, n = 4; foraminal space, n = 3; concurrent perivertebral soft tissue and perivertebral vein, n = 1; concurrent perivertebral vein and epidural space, n = 1</p> <p><i>PVP</i>, 88% (21/24 cases) perivertebral soft-tissue, n = 8; perivertebral vein, n = 7; epidural space, n = 1;</p>

					<p>discal space, n = 1; concurrent intradural and epidural space, n = 1; concurrent perivertebral soft tissue and perivertebral vein, n = 1; concurrent perivertebral vein and inferior vena cava, n = 1; psoas muscle, n = 1</p> <p>Local leakage rate was significantly higher for PVP as compared with KP, 88% vs. 49%, $P < .005$</p> <p>Pulmonary artery embolism of bone cement KP, n = 1 VP, n = 1 (and secondary pulmonary infarction)</p>
Fourney (2003)	Retrospective cohort	Frankel grades (ambulatory status) for entire population only; PVP and KP groups not reported separately	<p>Pain relief (refers to an analysis of documented VAS pain scores within first 24 hours)</p> <p><i>Complete</i> PVP: n = 8 (23%) KP: n = 1 (7%)</p> <p><i>Improved</i> PVP: n = 22 (63%) KP: n = 11 (73%)</p> <p><i>No change</i> PVP: n = 3 (9%) KP: n = 1 (7%)</p> <p><i>Worse</i> PVP: n = 0 KP: n = 0</p>	Vertebral body height and kyphosis correction; only reported for KP group, no comparison to VP	<p>Extrusion of PMMA noted of fluoroscopy during procedure PVP: n = 6 KP: n = 0</p> <p>Extravasation of PMMA into anterior perivertebral soft tissues VP: n = 1 KP: n = 0 into epidural space VP: n = 0 KP: n = 0 into neural foramen VP: n = 0 KP: n = 0</p>

			<i>Data unavailable</i> PVP: n = 2 (6%) KP: n = 2 (13%)		No deaths, intraoperative or perioperative complications were reported
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KP: balloon kyphoplasty; ODI: Oswestry Disability Index; OVCF: osteoporotic vertebral compression fractures; NR = not reported; NS = not statistically significant; PMMA: polymethylmethacrylate; PV: percutaneous vertebroplasty; VAS: Visual Analog Scale.

*Pain score: 1 = no pain/no analgesics, 2 = reduced pain/taking analgesics, 3 = no change in pain postoperatively, 4 = worse pain postoperatively. Scores were obtained 7 to 10 days after the procedure and used to account for pre- and postoperative morbidity.

†Vertebroplasty was performed in patients with osteoporosis, metastasis, and vertebral haemangioma. Only patients with osteoporosis were included for analysis.

‡Patients were asked to evaluate their activities of daily living (pain at rest, walking, sitting-standing, taking a shower, and putting on clothes). Each of the five activities was scored on a scale of 0-10 and added together to create an overall VAS pain score.

APPENDIX H: CLINICAL AND PEER REVIEWERS

Reviewer	Areas of expertise
<p>Brian M. Drew, MD Assistant Clinical Professor Medical Director of Spine Unit Hamilton General Hospital (Ontario, Canada)</p>	<ul style="list-style-type: none"> • Evidence-based practice • Spine fracture care • Adult spinal surgery • Spinal cord injury and clearance
<p>Michael J. Lee, MD Assistant Professor Orthopaedics & Sports Medicine University of Washington</p>	<ul style="list-style-type: none"> • Orthopedic surgeon • Cadaveric/pathology correlation • Risk factor/complication evaluation
<p>Jeffrey G. Jarvik, MD, MPH Professor, Radiology and Neurosurgery Director, Radiology Health Services Research Section and CECORC Adjunct Professor, Health Services University of Washington</p>	<ul style="list-style-type: none"> • Neuroradiology and diagnostic radiology • Health services researcher (back pain, imaging, clinical prediction rules) • Technology assessment, diagnostic testing