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Original Article

Does the complication rate and treatment effect of balloon kyphoplasty and vertebroplasty differ in countries or specialties of operators?

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ABSTRACT

Purpose: Vertebral compression fracture results in back pain, kyphotic deformity, loss of vertebral height, and restriction in daily activity. Conservative treatment, including analgesics, bed rest, and bracing, did not show up for good clinical control. Recently, minimally invasive surgical techniques, such as kyphoplasty and vertebroplasty, could become popular because of quick relief of pain. The goal of this review is to find out whether the complication rates and treatment effects differ in countries or specialties of operators.

Materials and Methods: Detailed searches of electronic databases (i.e. Pubmed, Cochrane library) were performed from 1987 to April 2007. Outcome measures of efficacy included visual analog scale decrease, change in kyphotic angle, restoration of vertebral height, and improvement of functional capacity. Outcome measures of safety were cement leakage, new vertebral compression fracture, and complications.

Results: There is a trend of increasing publications regarding these two procedures, especially in vertebroplasty. We found a higher level of cement leakage rate in vertebroplasty than in kyphoplasty. We also found that reduction in kyphotic angle was better in kyphoplasty than in vertebroplasty. These results were compatible with other literatures. Cement leakage rates were lower in neurosurgery department (20.6%) and orthopedic department (24.7%) than radiology department (52.9%).

Conclusions: The procedure operated by orthopedic surgeons and neurosurgeons tend to have lower cement leakage rate. One possible reason was that the neurosurgeons and the orthopedic surgeons are more familiar with the anatomical information needed for the procedure. Another possible explanation was that the radiologists might have more sufficient data to report the complications than the clinicians.

1. Introduction

About 1.7 million vertebral compression fractures (VCFs) occur every year in the United States and in Europe.[10,27,28] VCFs might cause limited daily activity, kyphotic deformity, back pain, and loss of vertebral height.[5,6,18,22,25] Management options for treating VCF are limited. Depending on the clinical situations, conservative management consists of calcitonin, muscle relaxants, narcotic and non-narcotic pain medications, bed rest, and back braces.[24] However, further reduction of bone mass may be caused by immobilization. Elder people, especially patients with secondary osteoporosis from chronic obstructive pulmonary disease or rheumatoid arthritis, usually cannot tolerate bracing.[14] Other clinicians tried various kinds of metal implant.[16] Because of the poor quality of osteoporotic vertebral bodies (VBs), surgical fixation by means of metal implants often failed. Meanwhile, these procedures were limited to patients with neurological deficits because of the risk of open surgery in the elderly.[9]

Percutaneous vertebroplasty was developed in France in the late 1980s. It is a minimally invasive procedure that involves the percutaneous injection of polymethylmethacrylate into a fractured VB. Through a little incision, needles are inserted into the spine and polymethylmethacrylate bone cement is injected into the VB to reinforce and stabilize the structure. Although vertebroplasty does not reexpand a collapsed VB, it relieved pain immediately. This

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minimally invasive procedure was first used to treat aggressive vertebral hemangioma in 1987.[12] Later, vertebroplasty was used for various kinds of lesions weakening the VB, including osteoporotic VCFs and osteolytic metastases.[6,7,17,33,34] Most European experience with vertebroplasty includes spinal metastases and myeloma;[8,19,21,23] on the contrary, most North American case series are highly weighted toward osteoporotic VCF.[1,2,3,13] A recent multicenter, randomized, double-blind, placebo-controlled trial of vertebroplasty for painful osteoporotic vertebral fractures demonstrated surprising results. They found no beneficial effect of vertebroplasty as compared with a sham procedure in patients with painful osteoporotic vertebral fractures, at 1 week or at 1 month, 3 months, or 6 months after treatment.[4]

Adverse events during or after percutaneous vertebroplasty include extravasation of bone cement into vascular or adjacent structures, new VCFs, increase in back pain, radiculopathy, infection, and pulmonary distress.

The term "kyphoplasty" was introduced by Kyphon Inc. (Sunnyvale, CA, USA). This technique is performed in the operating room by means of a specific fracture reduction system (Kyphon Inc.).[4] Balloon kyphoplasty was first used in 1998 and involves fracture reduction using inflation bone tamps to restore VB height. These two bone tamps create a vacuum in the VB that could be filled under low pressure with high viscosity bone cement.[29,30] One study found that the incidence of new VCFs after kyphoplasty is greater than that of untreated VCFs.[11] However, their finding had been criticized because of the poor methodology of their studies.[15]

In recent years, percutaneous vertebroplasty and balloon kyphoplasty have been widely adopted in clinical practice because of immediate pain relief.[26] However, there have been no randomized controlled trials regarding these two procedures. There are also no articles discussing the possible different prognosis and complication rates between countries or specialties of operators. Therefore, the goal of this review is to find out whether the complication rates and treatment effects of vertebroplasty and kyphoplasty differ in countries or specialties of operators.

2. Material and methods

2.1. Literature search

For the identification of studies, we performed a systematic review of the literature from 1987 to April 2007, involving MEDLINE (Ovid) and Cochrane Library database. Search terms were selected to maximize both the search sensitivity and specificity. Search was restricted to English-language report. The studies that met the inclusion criteria were independently examined by two reviewers to discard publication duplicity or redundancy. During the trial selection and data extraction, we were not masked to authors, institutions, journals, or intervention assessed. Masking may hinder efforts to avoid duplication and ensure data completeness.

2.2. Study selection and inclusion criteria

We reviewed various kinds of studies, included experimental studies (i.e. randomized and nonrandomized trials), observational studies (i.e. cohort studies, case control studies, or cross-sectional studies), and uncontrolled studies (i.e. case series). The treatment modalities consisted of balloon kyphoplasty or percutaneous vertebroplasty. In terms of study population, patients with VCFs of osteoporotic, neoplastic (i.e. myeloma, metastases, or osteolysis), or traumatic etiology were all included.

The enrolled studies must report at least one of the following: efficacy, pain relief, functional capacity, health-related quality of life, deformity correction (height restoration, kyphotic angle correction), safety, cement leakage, new VCF, and complications. Biomechanical studies, technical reports, reviews, and comments were excluded.

3. Results

3.1. Identification and selection of studies

For balloon kyphoplasty, a total of 288 citations were obtained from searches of the various electronic bibliographies. Thirty-seven case series met the inclusion criteria. For vertebroplasty, a total of 798 citations were obtained from searches of the electronic bibliographies. Eighty case series met the inclusion criteria. The study selection process and reasons for exclusion are summarized in Fig. 1.

3.2. Balloon kyphoplasty

3.2.1. Study characteristics

A total of 1,982 patients (2,637 vertebral fractures) were included in 37 case series. Sample size varied considerably across the studies. Regarding the publication year of the case series, there were 1 case series published in 2001, 1 in 2002, 4 in 2003, 6 in 2004, 12 in 2005, 12 in 2006, and 1 in 2007 (Fig. 2). There is a trend of increasing publications in balloon kyphoplasty. Regarding the department of the first authors of the case series, there were 20 orthopedic surgeons, 7 neurosurgeons, 2 physicians, 6 radiologists, and 2 trauma surgeons (Fig. 3).

3.2.2. Efficacy outcomes

Among 37 case series, there were 21 studies reported with visual analog scale (VAS) decrease. The average VAS reduction was 5.33. Three case series used the Short-Form 36 to assess the quality of life. The average change of these life quality parameter was 33.43 in bodily pain, 27.33 in physical function, 11.00 in general health (only 1 case series), 15.77 in vitality, 28.20 in social functioning, 24.00 in role emotional (1 case series), 12.45 in mental health, and 26.30 in role functioning (2 case series). The average increase in vertebral height was 16.00% of original height in anterior portion of VB (9 case series), 16.88% in middle portion (12 case series), and 5.50% in posterior portion (2 case series). The average reduction in kyphotic angle was 7.49° (13 case series) (Table 1).

3.2.3. Safety outcomes

There were 20 case series reported with cement leakages. The average cement leakage rate was 12.26%. Four case series reported the new VCFs and the incidence was 10.46%. Pulmonary embolism was reported in eight case series and the incidence was 0.58%. Radiculopathy was reported in eight case series and the incidence was 0.06% (Table 2).

Cement leakage rate was around 8.6% (70 patients) in 2001, 3.6% (55 patients) in 2002, 7.5% (438 patients) in 2003, 9.5% (440 patients) in 2004, 11.3% (532 patients) in 2005, 11.0% (339 patients) in 2006, and 12.5% (64 patients) in 2007 (Fig. 4). Cement leakage rate was 9.0% (1,341 patients) in orthopedic department, 6.0% (365 patients) in neurosurgery department, 15.5% (110 patients) in medicine department, 17.9% (56 patients) in radiology department, and 27.3% (66 patients) in trauma surgery department (Fig. 5).

Cement leakages were about 9.1% (1,245 patients) in the United States, 18.2% (33 patients) in Switzerland, 10.5% (599 patients) in Germany, and 9.8% (61 patients) in Greece (Fig. 6). Cement leakages were 10.9% (693 patients) in Europe and 9.1% (1,245 patients) in America (Fig. 7).

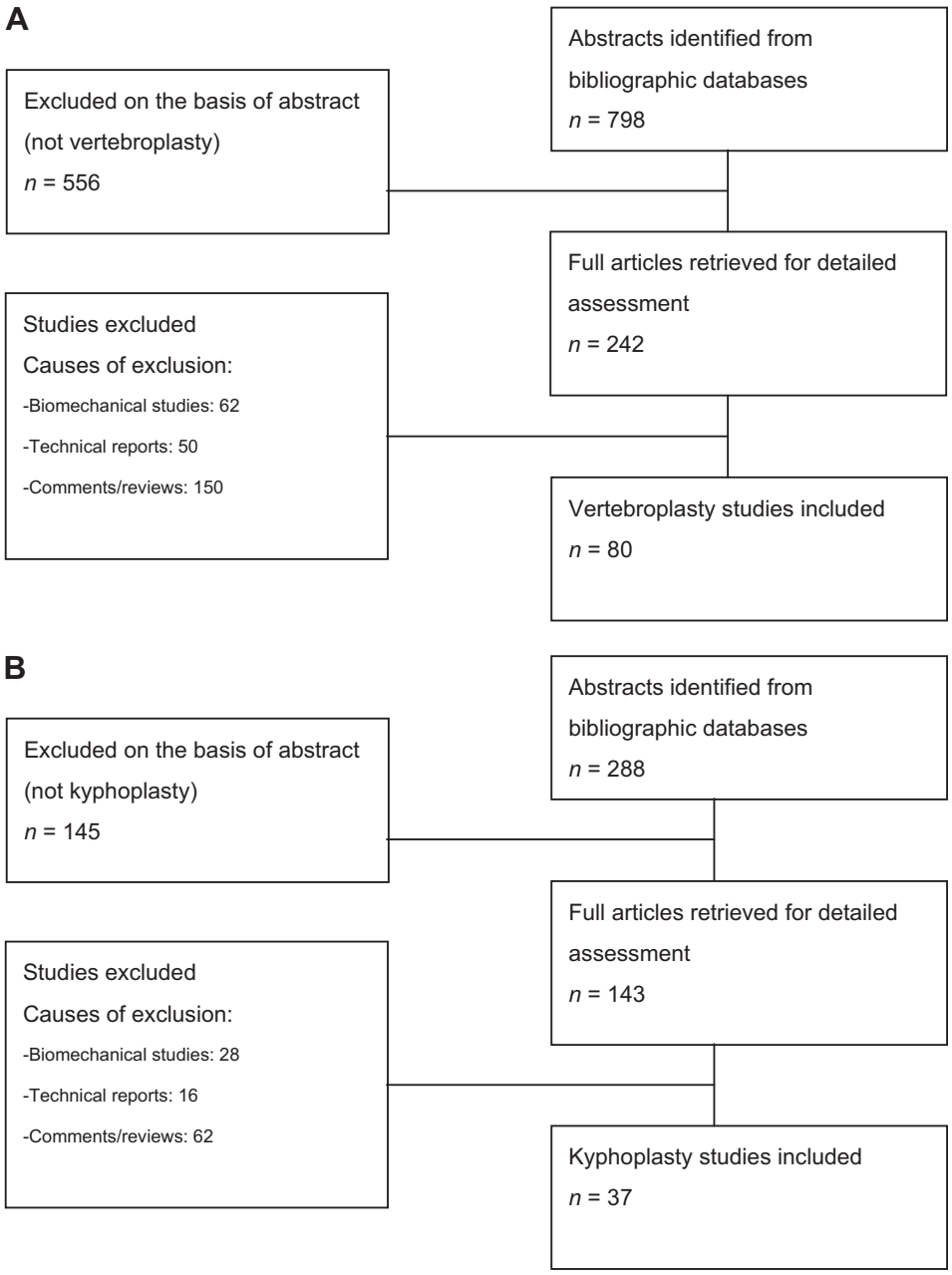

Fig. 1. (A) Summary of study selection and exclusion process for vertebroplasty. (B) Summary of study selection and exclusion process for kyphoplasty.

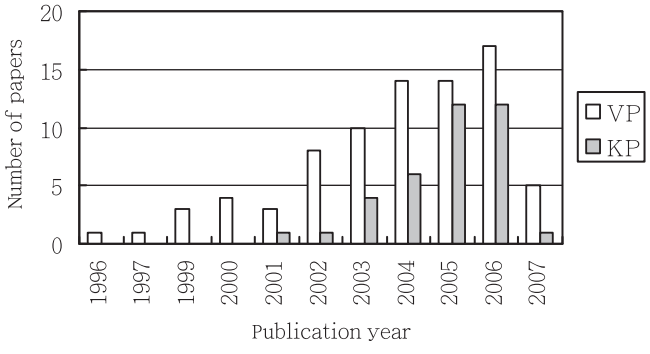

Fig. 2. Number of articles regarding KP and VP in each year. KP = kyphoplasty; VP = vertebroplasty.

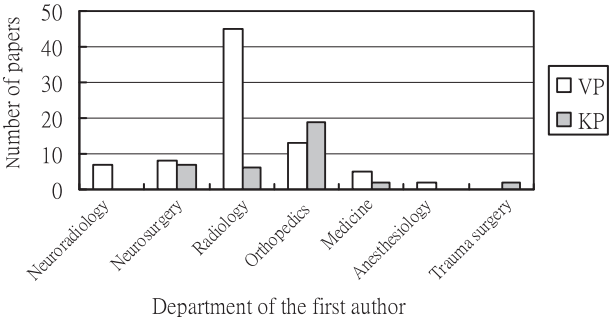

Fig. 3. Number of articles regarding KP and VP in different departments. KP = kyphoplasty; VP = vertebroplasty.

Table 1
Summary of case series efficacy outcomes.

Efficacy outcomes	Kyphoplasty ($n = 37$)		Vertebroplasty ($n = 80$)		p[a]
	n	Mean ± SD	n	Mean ± SD	
Change in pain (VAS 0–10 mm scale)	21	5.33 ± 1.35	40	5.65 ± 1.26	0.374
Change in quality of life (SF-36)					
Bodily pain	3	33.43 ± 13.10	1	26.0	
Physical function	3	27.33 ± 9.50	1	10.4	
General health	1	11.0	Not reported		
Vitality	3	15.77 ± 7.56	1	16.9	
Social functioning	3	28.20 ± 10.77	1	23.7	
Role emotional	1	24.0	1	29.0	
Mental health	2	12.45 ± 0.78	1	12.3	
Role functioning	2	26.30 ± 3.25	1	22.7	
Change in vertebral height (% original height)					
Anterior	9	16.00 ± 8.28	3	18.37 ± 9.51	0.725
Middle	12	16.88 ± 9.70	3	18.43 ± 10.94	0.843
Posterior	2	5.50 ± 3.54	3	6.66 ± 3.07	0.742
Change in kyphotic angle (reduction in degrees)	13	7.49 ± 3.33	9	4.15 ± 1.76	0.007*

[a] Two-sample t test was performed.
*$p < 0.05$; significant finding.
SD = standard deviation; SF-36 = Short Form 36; VAS = visual analog scale.

3.3. Percutaneous vertebroplasty

3.3.1. Study characteristics

A total of 6,141 patients (8,138 vertebral fractures) were included in 80 case series. Sample size varied considerably across the studies. Regarding the department of the first authors of the case series, there were 7 neuroradiologists, 8 neurosurgeons, 45 radiologists, 13 orthopedic surgeons, 5 physicians, and 2 anesthesiologists (Fig. 3). Regarding the publication year of the case series, there were 1 case series published in 1996, 1 in 1997, 3 in 1999, 4 in 2000, 3 in 2001, 8 in 2002, 10 in 2003, 14 in 2004, 14 in 2005, 17 in 2006, and 5 in 2007 (Fig. 2). There is a trend of increasing publications in percutaneous vertebroplasty as in kyphoplasty.

3.3.2. Efficacy outcomes

Among 80 case series, there were 40 studies reported with VAS decrease. The average VAS reduction was 5.65. Only one case series used the Short-Form 36 to assess the quality of life. The average change of these life quality parameter was 26.00 in bodily pain, 10.40 in physical function, not reported in general health, 16.90 in vitality, 23.70 in social functioning, 29.00 in role emotional, 12.30 in mental health, and 22.70 in role functioning. The average increase in vertebral height was 18.37% of original height in anterior portion of VB (3 case series), 18.43% in middle portion (3 case series), and 6.66% in posterior portion (3 case series). The average reduction in kyphotic angle was 4.15° (9 case series) (Table 1).

Table 2
Summary of case series safety outcomes.

Safety outcomes	Kyphoplasty ($n = 37$)		Vertebroplasty ($n = 80$)		p[a]
	n	Rate (%)	n	Rate (%)	
Cement leakages	20	12.26 ± 7.91	40	36.44 ± 28.76	0.000*
New VCFs	4	10.46 ± 2.49	21	21.47 ± 14.67	0.004*
Pulmonary embolism	8	0.58 ± 1.63	7	3.41 ± 2.35	0.023*
Radiculopathy	8	0.06 ± 0.16	17	4.22 ± 3.87	0.000*

[a] Two-sample t test was performed.
*$p < 0.05$; significant finding.
VCF = vertebral compression fracture.

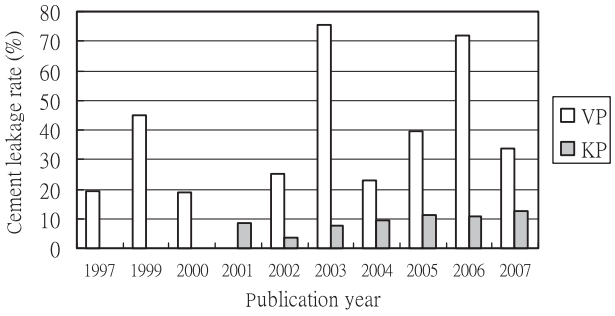

Fig. 4. Cement leakage rate in different publication years. KP = kyphoplasty; VP = vertebroplasty.

3.3.3. Safety outcomes

There were 40 case series reported with cement leakages. The average cement leakage rate was 36.44%. Twenty-one case series reported the new VCFs and the incidence was 21.47%. Pulmonary embolism was reported in seven case series and the incidence was 3.41%. Radiculopathy was reported in 17 case series and the incidence was 4.22% (Table 2).

Cement leakage rate was around 19.1% (47 patients) in 1997, 45% (40 patients) in 1999, 19.0% (79 patients) in 2000, 25.4% (418 patients) in 2002, 75.3% (441 patients) in 2003, 23.1% (299 patients) in 2004, 40.0% (1006 patients) in 2005, 72.1% (1096 patients) in 2006, and 33.9% (655 patients) in 2007 (Fig. 4). Cement leakage rate was 24.7% (360 patients) in orthopedic department, 20.9% (206 patients) in neurosurgery department, 38.2% (55 patients) in medicine department, 52.9% (3098 patients) in radiology department, 2.9% (34 patients) in anesthesiology department, and 50.9% (328 patients) in neuroradiology department (Fig. 5).

Cement leakages were about 98.7% (528 patients) in France, 25.8% (1,092 patients) in the United States, 52.3% (819 patients) in Switzerland, 57.6% (205 patients) in Spain, 36.4% (206 patients) in Korea, 0% (51 patients) in China, 14.3% (84 patients) in Taiwan, 13.8% (65 patients) in India, 66.4% (500 patients) in Japan, 0% (7 patients) in Australia, 14.4% (132 patients) in Canada, 42.3% (326 patients) in Germany, and 40.9% (66 patients) in Israel (Fig. 6). Cement leakages were 64.2% (1,878 patients) in Europe, 24.6% (1,224 patients) in United States, 49.0% (928 patients) in Asia except China, and 0% (51 patients) in China (Fig. 7).

4. Discussion

This review included 37 case series of kyphoplasty study and 80 case series of vertebroplasty. Compared with a previous systematic review of kyphoplasty and vertebroplasty published in 2006,[4] we have found some additional studies.

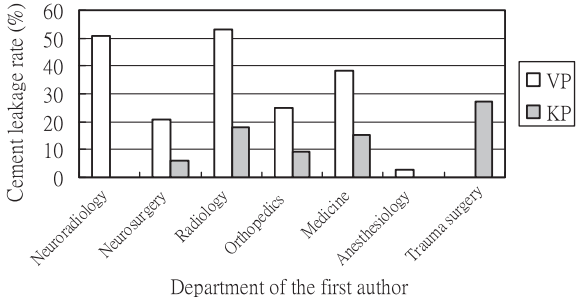

Fig. 5. Cement leakage rate in different departments. KP = kyphoplasty; VP = vertebroplasty.

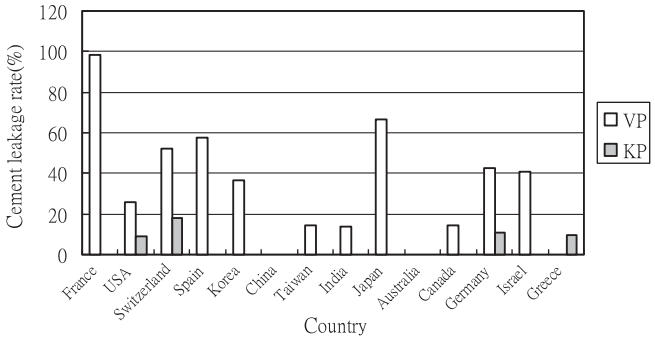

Fig. 6. Cement leakage rate in different countries. KP = kyphoplasty; VP = vertebroplasty.

For kyphoplasty, 21 case series reported the magnitude of VAS decrease, which was 5.33 in average. Meanwhile, the previous review showed that the amount of VAS decrease was 4.0 in average (7 case series). It might imply that the technique of kyphoplasty improved gradually. Thirteen case series reported kyphotic angle reduction with the average of 7.49°; the previous review showed 7° of kyphotic angle reduction (4 case series). Twenty case series reported cement leakages. The overall cement leakage rate for kyphoplasty in our review was 12.26%. In the previous review, it was 8.0%. Four case series reported new VCFs. The incidence of new VCFs was 10.46% in our review and 20.3% in the previous review. There were also some adverse events with kyphoplasty, unfortunately. The incidence of pulmonary embolism and radiculopathy were 0.58% and 0.06%, respectively. In the previous review, the incidence of pulmonary embolism and radiculopathy were 0.3% and 0.3%, respectively.

For vertebroplasty, 40 case series reported the magnitude of VAS decrease. The average was 5.65. In the previous review, the average of VAS decrease was 5.8. Nine case series reported kyphotic angle reduction with the average of 4.15°. In comparison, the previous review revealed the average of 4.0° (2 case series). The overall cement leakage rate for vertebroplasty in our review was 36.44%. In the previous review, it was 40.0%. Twenty-one case series reported new VCFs. The incidence of new VCFs was 21.47% in our review and 10.2% in the previous review. The incidence of pulmonary embolism and radiculopathy were 3.41% and 4.22%, respectively. In the previous review, the incidence of pulmonary embolism and radiculopathy were 1.8% and 2.5%, respectively.

Therefore, we found no significant difference of VAS decrease and vertebral height improvement between kyphoplasty and vertebroplasty. A higher level of kyphotic angle reduction was found in kyphoplasty than in vertebroplasty. Still, a higher level of cement leakage rate was found in vertebroplasty than in kyphoplasty. Interestingly, a higher incidence of new VCFs was found in vertebroplasty. On the contrary, a higher incidence of new VCFs was found in kyphoplasty in the previous review.

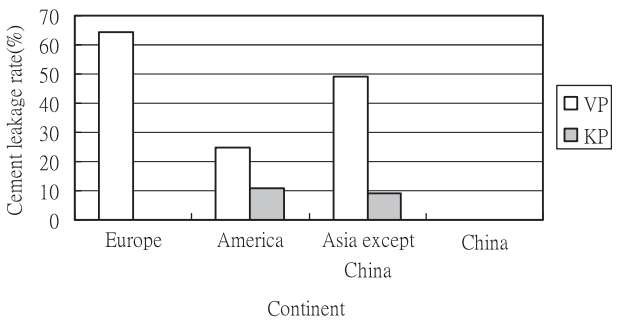

Fig. 7. Cement leakage rate in different continents. KP = kyphoplasty; VP = vertebroplasty.

There is no trend of decreasing cement leakage rate in vertebroplasty (Fig. 4). One possible reason was that more and more surgeons did vertebroplasty and the overall cement leakage rates could not decline because of the "learning curve" of the beginners.

Cement leakage rates were lower in neurosurgery department (20.6%) and orthopedic department (24.7%) than radiology department (52.9%). One possible reason was that neurosurgeons and orthopedic surgeons are more familiar with the anatomical information needed for the procedure. Another possible explanation was that the radiologists might have more sufficient data to report the complications than clinicians.

4.1. Publication bias

Studies with positive results are prone to be published, and adverse events or side effects are more likely to be underreported (for example, 0% cement leakage rate was reported in China). It is so-called "publication bias." Any review cannot avoid the publication bias. For example, in our review, we found that a higher percentage of kyphoplasty publications (54.1%) included cement leakages as the endpoint than vertebroplasty publications (50%).

In terms of safety, we might reduce complication rate by means of the application of high-resolution radiological techniques during the procedure, the selection of patients, the injection of bone cement in a proper state of polymerization, and good surgeon training.[20,31,32]

4.2. Pain

Pain relief because of kyphoplasty and vertebroplasty is widely measured by a standardized 11-point VAS. "No pain at all" and "the most pain imaginable" are assigned values of 0 and 10, respectively. Pain relief might persist up to 1 year and possibly to 2 years. The mechanism of pain relief is under debating. One possible explanation is that cessation of vertebral micromotion could be achieved by installation of bone cement.

4.3. Study limitation

The results might differ depending on choosing first author or corresponding author representing the specialty. This is one of study limitations. We finally decided to choose first author representing the specialty. Besides, the difference of cement leakage rates between different years might be a confounding factor.

To conclude, the procedure operated by orthopedic surgeons and neurosurgeons tend to have lower cement leakage rate. One possible reason was that neurosurgeons and orthopedic surgeons are more familiar with the anatomical information needed for the procedure. Another possible explanation was that radiologists might have more sufficient data to report the complications than clinicians.

References

1. A.P. Amar, D.W. Larsen, N. Esnaashari, F.C. Albuquerque, S.D. Lavine, G.P. Teitelbaum. Percutaneous transpedicular polymethylmethacrylate vertebroplasty for the treatment of spinal compression fractures. Neurosurgery 49 (2001) 1105–1114.
2. J.D. Barr, M.S. Barr, T.J. Lemley, R.M. McCann. Percutaneous vertebroplasty for pain relief and spinal stabilization. Spine 25 (2000) 923–928.
3. C. Bouza, T. Lopez, A. Magro, L. Navalpotro, J.M. Amate. Efficacy and safety of balloon kyphoplasty in the treatment of vertebral compression fractures: a systematic review. Eur Spine J 15 (2006) 1050–1067.
4. R. Buchbinder, R.H. Osborne, P.R. Ebeling, J.D. Wark, P. Mitchell, C. Wriedt, S. Graves, et al. A randomized trial of vertebroplasty for painful osteoporotic vertebral fractures. N Engl J Med 361 (2009) 557–568.

5. E. Chrischilles, T. Shireman, R. Wallace. Costs and health effects of osteoporotic fractures. Bone 15 (1994) 377–386.
6. C. Cooper, E.J. Atkinson, W.M. O'Fallon, L.J. Melton 3rd. Incidence of clinically diagnosed vertebral fractures: a population-based study in Rochester, Minnesota, 1985-1989. J Bone Miner Res 7 (1992) 221–227.
7. A. Cotten, F. Dewatre, B. Cortet, R. Assaker, D. Leblond, B. Duquesnoy, P. Chastanet, et al. Percutaneous vertebroplasty for osteolytic metastases and myeloma: effects of the percentage of lesion filling and the leakage of methyl methacrylate at clinical follow-up. Radiology 200 (1996) 525–530.
8. H. Deramond, C. Depriester, P. Galibert, D. Le Gars. Percutaneous vertebroplasty with polymethylmethacrylate. Technique, indications, and results. Radiol Clin North Am 36 (1998) 533–546.
9. C.A. Dickman, R.G. Fessler, M. MacMillan, R.W. Haid. Transpedicular screw-rod fixation of the lumbar spine: operative technique and outcome in 104 cases. J Neurosurg 77 (1992) 860–870.
10. H.W. Finnern, D.P. Sykes. The hospital cost of vertebral fractures in the EU: estimates using national datasets. Osteoporos Int 14 (2003) 429–436.
11. D. Fribourg, C. Tang, P. Sra, R. Delamarter, H. Bae. Incidence of subsequent vertebral fracture after kyphoplasty. Spine 29 (2004) 2270–2276.
12. P. Galibert, H. Deramond, P. Rosat, D. Le Gars. [Preliminary note on the treatment of vertebral angioma by percutaneous acrylic vertebroplasty]. Neurochirurgie 33 (1987) 166–168.
13. A. Gangi, B.A. Kastler, J.L. Dietemann. Percutaneous vertebroplasty guided by a combination of CT and fluoroscopy. AJNR Am J Neuroradiol 15 (1994) 83–86.
14. J.G. Grohs, M. Matzner, K. Trieb, P. Krepler. Minimal invasive stabilization of osteoporotic vertebral fractures: a prospective nonrandomized comparison of vertebroplasty and balloon kyphoplasty. J Spinal Disord Tech 18 (2005) 238–242.
15. J.S. Harrop, B. Prpa, M.K. Reinhardt, I. Lieberman. Primary and secondary osteoporosis' incidence of subsequent vertebral compression fractures after kyphoplasty. Spine 29 (2004) 2120–2125.
16. S.S. Hu. Internal fixation in the osteoporotic spine. Spine 22 (24 Suppl) (1997) 43S–48S.
17. M.E. Jensen, A.J. Evans, J.M. Mathis, D.F. Kallmes, H.J. Cloft, J.E. Dion. Percutaneous polymethylmethacrylate vertebroplasty in the treatment of osteoporotic vertebral body compression fractures: technical aspects. AJNR Am J Neuroradiol 18 (1997) 1897–1904.
18. O. Johnell, B. Gullberg, J.A. Kanis. The hospital burden of vertebral fracture in Europe: a study of national register sources. Osteoporos Int 7 (1997) 138–144.
19. P. Kaemmerlen, P. Thiesse, P. Jonas, C.L. Bérard, J. Duquesnel, Y. Bascoulergue, C. Lapras. Percutaneous injection of orthopedic cement in metastatic vertebral lesions. N Engl J Med 321 (1989) 121.
20. J.D. Kang, H. An, S. Boden, F. Phillips, K. Foley, W. Abdu. Cement augmentation of osteoporotic compression fractures and intraoperative navigation: summary statement. Spine 28 (15 Suppl) (2003) S62–S63.
21. J.B. Martin, B. Jean, K. Sugiu, D. San Millán Ruíz, M. Piotin, K. Murphy, B. Rüfenacht, et al. Vertebroplasty: clinical experience and follow-up results. Bone 25 (2 Suppl) (1999) 11S–15S.
22. L.J. Melton 3rd, E.J. Atkinson, W.M. O'Fallon, H.W. Wahner, B.L. Riggs. Long-term fracture prediction by bone mineral assessed at different skeletal sites. J Bone Miner Res 8 (1993) 1227–1233.
23. K.J. Murphy, H. Deramond. Percutaneous vertebroplasty in benign and malignant disease. Neuroimaging Clin N Am 10 (2000) 535–545.
24. J.L. Old, M. Calvert. Vertebral compression fractures in the elderly. Am Fam Physician 69 (2004) 111–116.
25. F.M. Phillips. Minimally invasive treatments of osteoporotic vertebral compression fractures. Spine 28 (15 Suppl) (2003) S45–S53.
26. F.M. Phillips, W.F. Todd, I. Lieberman, M. Campbell-Hupp. An in vivo comparison of the potential for extravertebral cement leak after vertebroplasty and kyphoplasty. Spine 27 (2002) 2173–2178.
27. N.F. Ray, J.K. Chan, M. Thamer, L.J. Melton 3rd. Medical expenditures for the treatment of osteoporotic fractures in the United States in 1995: report from the National Osteoporosis Foundation. J Bone Miner Res 12 (1997) 24–35.
28. D.K. Roy, T.W. O'Neill, J.D. Finn, M. Lunt, A.J. Silman, D. Felsenberg, G. Armbrecht, et al. Determinants of incident vertebral fracture in men and women: results from the European Prospective Osteoporosis Study (EPOS). Osteoporos Int 14 (2003) 19–26.
29. R.S. Taylor, P. Fritzell, R.J. Taylor. Balloon kyphoplasty in the management of vertebral compression fractures: an updated systematic review and meta-analysis. Eur Spine J 16 (2007) 1085–1100.
30. R.S. Taylor, J.P. Van Buyten, E. Buchser. Spinal cord stimulation for chronic back and leg pain and failed back surgery syndrome: a systematic review and analysis of prognostic factors. Spine 30 (2005) 152–160.
31. E. Truumees, A. Hilibrand, A.R. Vaccaro. Percutaneous vertebral augmentation. Spine J 4 (2004) 218–229.
32. N.B. Watts, S.T. Harris, H.K. Genant. Treatment of painful osteoporotic vertebral fractures with percutaneous vertebroplasty or kyphoplasty. Osteoporos Int 12 (2001) 429–437.
33. A. Weill, J. Chiras, J.M. Simon, M. Rose, T. Sola-Martinez, E. Enkaoua. Spinal metastases: indications for and results of percutaneous injection of acrylic surgical cement. Radiology 199 (1996) 241–247.
34. M. Wenger, T.M. Markwalder. Surgically controlled, transpedicular methyl methacrylate vertebroplasty with fluoroscopic guidance. Acta Neurochir (Wien) 141 (1999) 625–631.