The increasing elderly population throughout the globe has brought increasing attention to osteoporosis, the most important cause of osteoporotic vertebral compression fractures (OVCF). 1,2 OVCF has a prevalence of more than 30% in the population older than 65 years.3 OVCF is associated with acute and chronic pain, progressive spinal deformity, a decreased quality of life, impaired physical function and increasing mortality.4-8

One method to treat OVCF is conservative non-surgical management (NSM) which consists of bed rest, use of painkillers, and bracing.9 However, NSM does not improve vertebral height10 or reverse kyphotic deformities, and has undesirable effects such as bedsores, bone demineralization and deep vein thrombosis.11 Since 1987, vertebroplasty (VP) and kyphoplasty (KP) with polymethylmethacrylate (PMMA) augmentation has been increasingly advocated as treatment for...
OVCF. Both of these minimally invasive techniques increase bone strength and reduce pain. Recently, two randomized controlled trials (RCT) showed that both methods were effective in reducing immediate pain, unlike conservative treatment. Several studies have shown that KP achieves better restoration of the kyphotic angle and vertebral height compared with VP. Furthermore, KP reduced the cement leakage rate compared with VP.

The comparative effectiveness and complications of KP and VP have been assessed in a few systematic reviews and meta-analysis, all which pooled randomized controlled trials with observational studies. This systematic review updates previous analyses.

**PATIENTS AND METHODS**

**Literature search**

We performed a comprehensive systematic computer-based literature search of published reports before August 2015 in PubMed, EMBASE and the Cochrane Central Register of Controlled Trials (CENTRAL). The reference lists of the selected studies were also searched. The search terms were: “kyphoplasty” or “KP” AND “vertebroplasty” or “VP” AND “vertebral fracture” AND “osteoporotic” or “osteoporosis”. We selected randomized controlled trials (RCTs) and prospective and retrospective cohort studies that compared KP with VP with no language restrictions. The protocol was not registered.

**Inclusion/Exclusion criteria**

The inclusion criteria were that studies be comparative studies (RCTs, prospective and retrospective cohort studies) comparing KP and VP in patients with OVCF. Outcomes had to include the postoperative time to injury, the duration of the operation, pain relief and quality of life, postoperative radiographic data and complications. Studies were excluded from our meta-analysis if they were of vertebral fractures caused by any etiology other than osteoporosis, including neoplastic or invasive, infective and traumatic fracture. Studies involving any type of cement other than PMMA cement were excluded.

**Quality assessment and data extraction**

RCTs were carefully assessed by two authors (LL and XLC) and any disagreement resolved through discussion. Determination of the risk of bias in the RCTs included the following key domains: adequate sequence generation, allocation concealment, blinding, incomplete outcome data, free from selective reporting, and free from other bias. The prospective and retrospective cohort studies were assessed by the methodological index for non-randomized studies (MINORS), a validated instrument designed to assess the quality of comparative or non-comparative non-RCT studies. LL and XLC independently extracted the data from each article with a standard data extraction form. The data included authors, year of publication, study design, age of population, gender, numbers of vertebral bodies, surgical procedures, duration of follow-up and outcomes parameters. The extracted data were analyzed by YYZ.

**Clinical outcomes**

Pain intensity and functional disability was measured using the visual analog scale (VAS) and the Oswestry Disability Index (ODI). Radiographic outcomes included the height of the vertebral body (anterior, middle and posterior) and the kyphotic angle. Complication outcomes were cement leakage and new vertebral fracture.

Injury time, operation time and the volume of injected cement were also extracted from the reports.

VAS and ODI were extracted and summarized by short-term (less than one week) and long-term (more than six months) follow-up. We defined the short-term period as less than one week and the long-term period as no less than 6 months. If there were several time points in the long-term follow-up, we selected the longest follow-up. We defined the postoperative period as the first day after surgery and improvement as any change between the preoperative and postoperative periods.

**Statistical analysis**

We performed all meta-analysis with Stata version 12.0 (StataCorp, College Station, TX). For dichotomous outcomes, the odds ratio (OR) and the 95% confidence interval (95% CI) were assessed. For continuous outcomes, means and standard deviations were pooled to a weighted or standardized mean difference (WMD or SMD), a weighting by the individual variances for each study, and the 95% CI. A probability of P<.05 was regarded as statistically significant. Statistical heterogeneity was assessed using Q statistics. Analysis of the
outcomes was divided to subgroups according to the time or the region, if possible. For the variables - extra-
spinal and total leakage, adjacent and total new frac-
ture, posterior height-postoperation, we used a fixed-
effects model; for the rest, we used a random-effects
model.

RESULTS

Study characteristics

Of 1300 titles and abstracts reviewed preliminarily, 32
met the inclusion criteria for the meta-analysis.17,26-56
(Figure 1). They included 4 RCTs,27,31,41,53 14 prospec-
tive cohort studies,17,32,36,39,40,41,49,54 and 14 retrospec-
tive cohort studies26,28-30,34,35,37,38,42,50-52,55,56 (Figures 2 and
3). There were a total of 3274 patients; 1653 patients
underwent the KP surgery and 1621 underwent VP sur-
gery. Individual study sample sizes ranged from 41 to
381 patients. The demographic characteristics of pa-
tients are summarized in Table 1.

Clinical outcomes

Eighteen studies reported short-term follow-up VAS
scores.17,28,30,31,33,35,36,38-42,47,49-52 There was a significant
difference between KP and VP (WMD=-0.2, 95% CI=-
0.27 to -0.63; P<.01). Long-term VAS scores were avail-
able from 14 studies.17,28,30,32,35,36,38,41,45,47,49,51 The pooled
result also showed a significant difference between the
two groups (WMD=-0.46, 95% CI=-0.57 to -0.36; P<.01)
(Figure 4 and Table 2). Adequate data on short-term
ODI scores was present in 7 studiess17,31,35,38,39,47,50 and
the difference in overall estimate was statistically sig-
nificant (WMD-17.56, 95% CI=-18.07 to -17.05; P<.01). Eight studies provided long-term ODI data.17,30,35,36,38-
40,47 There was a significant difference between KP
and VP (WMD=-2.41, 95% CI=-3.44 to -1.38; P<.01)
(Figure 5 and Table 2).

The dates of injury were available for four tri-
als.40,41,48,55 The pooled results demonstrated no signific-
ificant difference between the KP and VP group (WMD=-
1.31, 95% CI=-3.37 to 0.75; P<.01). Five reports re-
ported the mean and standard deviation for operation
time.27,31,43,51 VP required less time for the surgical pro-
cedure (WMD=6.58, 95% CI=5.47 to 7.68; P<.01) than
the KP group (Table 2). The reported volume of inject-
ed cement analyzed in 12 studies26,27,38,39,41,44-46,52,53,55,56
was greater in the KP group (WMD=0.51, 95% CI=0.44
to 0.56; P<.01) (Figure 6 and Table 2).

Radiographic outcome

In the 14 studies that reported the postoperative an-
terior height of the vertebral body,17,26,28,30,35,36,41,43,47,48,50-53
Table 1. Patient demographic and study characteristics of the 32 studies in the meta-analysis.

| Study          | Country    | Year | Study design | Patient numbers | Age (years) | Follow-up period (KP/VP) (months) | MINORS scores |
|----------------|------------|------|--------------|-----------------|-------------|------------------------------------|---------------|
| Bozkurt et al  | Turkey     | 2014 | Retrospective| 200/96          | 57.5/57     | 40/14                              | 14            |
| Dohm et al     | United States | 2014 | RCT          | 191/190         | 75.6/70.5   | 24/-                                | -             |
| Dong et al     | China      | 2013 | Retrospective| 51/35           | 69.8/70.5   | 21.3/14                            | 14            |
| Dong et al     | China      | 2009 | Retrospective| 20/18           | 69.5/70.2   | 3/11                               | 11            |
| Ee et al       | England    | 2012 | Retrospective| 97/148          | 75/77       | 24/15                              | 15            |
| Endres et al   | Germany    | 2011 | RCT          | 20/21           | 63.3/71.3   | 5.8/-                              | -             |
| Figueiredo et al | Brazil   | 2011 | Prospective  | 22/30           | 73/77       | 6/-                                | 16            |
| Folman et al   | Israel     | 2011 | Prospective  | 31/14           | 70.7/75.6   | 12/16                              | 16            |
| Frankel et al  | United States | 2007 | Retrospective| 17/29           | 70/72       | 3.5 years/-                        | 14            |
| Gan et al      | China      | 2014 | Retrospective| 41/38           | 69.1/67.1   | 43.5/41.4                          | 15            |
| Grohs et al    | Austria    | 2005 | Prospective  | 28/23           | 70/70       | 24/-                               | 17            |
| Hiwatashi et al| Japan      | 2008 | Retrospective| 40/66           | 75/77       | NR/-                               | 13            |
| Kong et al     | China      | 2014 | Retrospective| 29/24           | 71.9/70.5   | 12/13                              | 13            |
| Kumar et al    | Canada     | 2009 | Prospective  | 24/28           | 73/78       | 42.3/42.2                          | 17            |
| Li et al       | China      | 2012 | Prospective  | 45/40           | 68.5/67.1   | 12/-                               | 17            |
| Liu JT et al   | Taiwan     | 2009 | RCT          | 50/50           | 72.3/74.3   | >6/-                               | -             |
| Liu T et al    | China      | 2013 | Retrospective| 40/60           | 68.5/62.5   | 1 week                             | 13            |
| Lovi et al     | Italy      | 2009 | Prospective  | 36/118          | 67.6/33m    | 17/-                               | 17            |
| Movrin et al   | Slovenia   | 2010 | Prospective  | 46/27           | 67.8/72.9   | 1 year                             | 16            |
| Omidi-Kashani  | Iran       | 2013 | Prospective  | 29/28           | 72.1/72.4   | 6m/-                               | 13            |
| Pflugmacher et al | Germany | 2005 | Prospective  | 22/20           | 67/65       | 12/-                               | 15            |
| Qian et al     | China      | 2012 | Prospective  | 53/9            | 66.2/3.9y   | 16/-                               | 16            |
| Rollinghoff et al | Germany | 2009 | Prospective  | 53/51           | 68.9/1y     | 17/-                               | 17            |
| Santiago et al | Spain      | 2009 | Prospective  | 30/30           | 65.9/73     | 1 year                             | 16            |
| Schofer et al  | Germany    | 2009 | Prospective  | 30/30           | 72.5/73.8   | 13.5/13.7                          | 17            |
| Sun et al      | China      | 2010 | Retrospective| 31/28           | 74.2/72.3   | 18/-                               | 14            |
| Wu et al       | China      | 2014 | Retrospective| 20/20           | 65.1/66.3   | 1 year                             | 15            |
| Yan et al      | China      | 2011 | Retrospective| 98/94           | 76.9/77.2   | 14.3/15.2                          | 14            |
| Yang et al     | Korea      | 2014 | RCT          | 112/109         | 73.4/73.3   | NR/-                               | -             |
| Yi et al       | China      | 2014 | Prospective  | 79/90           | 61.3/49.4m  | 16/-                               | 16            |
| Yokoyama et al | Japan      | 2013 | Retrospective| 38/28           | 75.5/74     | NR/-                               | 12            |
| Zhang et al    | China      | 2013 | Retrospective| 30/29           | 68.7/66.2   | 25/-                               | 13            |

NR = not reported. RCT = randomized controlled trial. Follow-up period is months unless reported otherwise.

The MINORS criteria include the following items: (1) a clearly stated aim; (2) inclusion of consecutive patients; (3) Prospective data collection; (4) endpoints appropriate to the aim of the study; (5) unbiased assessment of the study endpoint; (6) a follow-up period appropriate to the aims of the study; (7) less than 5% loss to follow-up; (8) Prospective calculation of the sample size; (9) an adequate control group; (10) contemporary groups; (11) baseline equivalence of groups; and (12) adequate statistical analysis. The items are scored as follows: 0 (not reported); 1 (reported but inadequate); 2 (reported and adequate). The ideal global score for comparative studies is 24.
**Table 2.** Meta-analysis of clinical outcomes comparing the KP and VP groups.

| Outcomes                        | No. of studies | No. of patients | Effect estimate (95% CI) | P     |
|---------------------------------|----------------|-----------------|--------------------------|-------|
| **Visual analog scale**         |                |                 |                          |       |
| Short-term                      | 18             | 1500            | -0.2 (-0.27, -0.13)      | <.01  |
| Long-term                       | 14             | 1071            | -0.46 (-0.57, -0.36)     | <.01  |
| **Oswestry Disability Index**   |                |                 |                          |       |
| Short-term                      | 7              | 430             | -17.56 (-18.07, -17.05)  | <.01  |
| Long-time                       | 8              | 676             | -2.41 (-3.44, -1.38)     | <.01  |
| Injury time                     | 4              | 311             | -1.31 (-3.37, 0.75)      | <.01  |
| Operation time                  | 5              | 716             | 6.58 (5.47, 7.68)        | <.01  |
| Volume of injected cement       | 12             | 1764            | 0.51 (0.44, 0.56)        | <.01  |

The effect estimate is weighted mean difference, CI=confidence interval.

there was a significant difference in the immediate postoperative follow-up period (WMD=2.55, 95% CI=2.33 to 2.78, P<.01), the final follow-up (WMD=2.79, 95% CI=2.39 to 3.19; P<.01) and improvement (WMD=5.91, 95% CI=5.19 to 6.64; P<.01) between the KP and VP groups, respectively. Patients who underwent the KP procedure had a better postoperative anterior height of the vertebral body than those who had the VP procedure (Table 3).

The pooled measures of middle height included the immediate postoperative follow-up period (WMD=2.44, 95% CI=2.14 to 2.73; P<.01) and the final follow-up (WMD=6.92, 95% CI=6.31 to 7.52; P<.01) in four studies and three studies, respectively. Both showed a significant difference and demonstrated that the KP group had a better result than the VP group for changes in anterior and middle vertebral height, but in three reports there was no significant difference in pooled posterior height between KP and VP (WMD=0.5, 95% CI=0.03 to 1.02; P=0.178/WMD=1.78, 95% CI=1.44 to 2.11; P=.033) (Table 3).

The kyphotic angle in the immediate postoperative was analyzed in 15 studies. The kyphotic angle improved more in the KP group than in the VP group (WMD=-2.5, 95% CI=-2.84 to -2.16; P<.01). Nine studies reported the kyphotic angle at the final follow-up (WMD=-1.7, 95% CI=-2.06 to -1.33; P<.01) and seven studies reported the kyphotic angle at the final follow-up (WMD=-1.7, 95% CI=-2.06 to -1.33; P<.01).
compared the improvement (WMD=4.76, 95% CI=4.19 to 5.32; P<.01). With the KP procedure there was more improvement in the kyphotic angle than with the VP procedure (Figure 7 and Table 3).

Complications
Cement leakage in the VP group was significantly more frequent than in the KP group in the intraspinal space (OR=0.5, 95% CI=0.3 to 0.85; P=.035) in the extraspinal space (OR=0.36, 95% CI=0.2 to 0.62; P=.15) in total leakage (OR=0.53, 95% CI=0.4 to 0.7; P=.051) (Figure 8 and Table 4). Thirteen studies reported complications related to fractures. There was no significant difference between the groups (OR=1.41, 95% CI=0.7 to 2.83; P=.283) (Table 4).

DISCUSSION
Our systematic review and meta-analysis included 4 randomized studies and 28 non-randomized studies that included 1653 patients treated with KP and 1621 patients treated with VP. The main outcome variables were pain intensity and dysfunction measured by VAS and ODI, kyphotic angle, and vertebral height at short-term and long-term follow-ups. Postoperative complications included new vertebral and adjacent fractures, as well as time of injury and duration of surgery.

Treatment of OVCF should lead to a lasting improvement in the pain. More than 90% of pain and dysfunction caused by OVCF can be relieved successfully by KP or VP. Both surgical procedures significantly relieve the pain and improved dysfunction in patients with OVCF. In our analysis, KP was more effective on the VAS and ODI assessments than the VP group. The mechanism of pain reduction reflected in Oswestry score improvements might result from the inhibition and immobility of micro-movements of the fractured vertebral body, as well as the cytotoxic effect of the PMMA cement.

We pooled the improvement in kyphotic angle and height, which included the anterior, middle and posterior vertebral body. Improvements in postoperative anterior and middle height were better in the KP group in the immediate postoperative period and at the final follow-up. Improvements in posterior height were similar. One study reported that a reduction in the kyphotic angle depends more on natural healing than surgical treatment. Hulme et al showed that the incidence of new vertebral fractures did not increase in osteoporotic patients who had suffered vertebral fractures. New vertebral fractures may relate to the sustained loss of bone mass seen in the osteoporotic population, rather than the surgical procedure itself.

Cement leakage does not usually result in clinical symptoms. In our experience, the high injection pressure and low viscosity of the cement leads to a higher incidence of cement leakage during VP than during KP. The KP procedure creates a hole in which to package
Table 3. Results of meta-analysis of radiological outcome measures.

| Outcomes                  | No. of studies | No. of patients | Effect estimate (95% CI) | P  |
|---------------------------|----------------|-----------------|--------------------------|----|
| **Anterior height**       |                |                 |                          |    |
| Postoperative follow-up   | 10             | 1020            | 2.55 (2.33, 2.78)        | <.01|
| Final follow-up           | 6              | 505             | 2.79 (2.39, 3.19)        | <.01|
| Improvement               | 4              | 797             | 5.91 (5.19, 6.64)        | <.01|
| **Middle height**         |                |                 |                          |    |
| Postoperative follow-up   | 4              | 386             | 2.44 (2.14, 2.73)        | <.01|
| Final follow-up           | 3              | 275             | 6.92 (6.31, 7.52)        | <.01|
| **Posterior height**      |                |                 |                          |    |
| Postoperative follow-up   | 3              | 344             | 0.5 (-0.03, 1.02)        | .178|
| Final follow-up           | 3              | 344             | 1.78 (1.44, 2.11)        | .033|
| **Kyphotic angle**        |                |                 |                          |    |
| Postoperative follow-up   | 15             | 1365            | -2.5 (-2.84, -2.16)      | <.01|
| Final follow-up           | 9              | 641             | -1.7 (-2.06, -1.33)      | <.01|
| Improvement               | 7              | 916             | 4.79 (4.19, 5.32)        | <.01|

Effect estimates are weighted mean difference, CI = confidence interval, postoperative means immediate postoperative follow-up period.

Table 4. Differences in complications between the VP and K groups.

| Outcomes                  | No. of studies | No. of patients | Effect estimate (95% CI) | P  |
|---------------------------|----------------|-----------------|--------------------------|----|
| **Leakage**               |                |                 |                          |    |
| Intraspinal               | 13             | 1503            | 0.5 (0.3, 0.85)          | .035|
| Extraspinal               | 12             | 1223            | 0.36 (0.21, 0.62)        | .15 |
| Total                     | 22             | 2773            | 0.53 (0.4, 0.7)          | .051|
| **New fractures**         |                |                 |                          |    |
| Adjacent                  | 9              | 1070            | 1.41 (0.7, 2.83)         | .283|
| Total                     | 13             | 1628            | 0.94 (0.59, 1.49)        | .248|

Effect estimates are weighted mean difference, CI = confidence interval.
the cement with the help of a balloon. The KP group had a lower frequency of leakage than the VP group in our analysis. The intraspinal and extravascular leakage were greater in the VP group.

An ideal meta-analysis would include only RCTs with little heterogeneity. However, RCTs are rare for surgical procedures. Patients will not usually agree to partake in a randomized surgical option. Every surgeon has his personal specialty and chooses the preferable procedure according to the specific condition. Because of the lack of RCTs, we included prospective and retrospective cohort studies of high quality and designed a baseline form to collect demographic characteristics in a manner that would limit the risk of bias.

In conclusion, we found that the KP procedure was more effective in pain relief, physical functional improvement, improving restoration of vertebral height and kyphotic angle with reduced cement leakage, but the KP surgery took longer and required a greater volume of injected cement. The KP procedure has a higher cost of hospitalization. Additional RCTs are needed to confirm these conclusions and to select the best surgical procedure for patients with OVCF.

**Disclosure of conflict of interest**
None.

**Acknowledgment**
This research was funded by the Natural Science Foundation of Jiangsu Province (BK20130274).
REFERENCES

1. Laurent M. Treatment of osteoporotic vertebral fractures. JAMA internal medicine. Apr 2014;174(4):641-642.

2. Wang E, Y H, Wang M, Huang C. Treatment of osteoporotic vertebral fractures with percutaneous kyphoplasty: A report of 196 cases. European Journal of Orthopaedic Surgery and Traumatology. 2015;25(4):417-422.

3. Bonnick SL. Osteoporosis in men and women. Clinical cornerstone. 2006;8(1):28-39.

4. Tang H, Zhao JD, Li Y, et al. Efficacy of percutaneous kyphoplasty in treating osteoporotic multithoracolumbar vertebral compression fractures. Orthopedics. Dec 2010;33(12):885.

5. Lyles KW, Gold DT, Shipp KM, Pieper CF, Martinez S, Mulhausen PL. Association of osteoporotic vertebral compression fractures with impaired functional status. The American journal of medicine. Jun 1993;94(6):595-603.

6. Olekas A, Lips P, Dawson A, et al. Health-related quality of life in postmenopausal women with low BMD with or without prevalent vertebral fractures. Journal of bone and mineral research. : the official journal of the American Society for Bone and Mineral Research. Jul 2000;15(7):1384-1392.

7. Cockerill W, Lunt M, Silman AJ, et al. Health-related quality of life and radiographic vertebral fracture. Osteoporosis international: a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA. Feb 2004;15(2):113-119.

8. Wang G, Yang H, Pan J. Osteoporotic vertebral compression fractures with osteonecrosis treated by kyphoplasty. Bone. 2010;47:5455-5456.

9. Rapado A. General management of vertebral fractures. Bone. Mar 1996;18(3 Suppl.):191S-196S.

10. Convertino VA, Bloomfield SA, Greenleaf JE. An overview of the issues: physiological and psychological aspects. Spine (Phila Pa 1976). 2009, 34: 1228-1238.

11. Takata S, Yasui N. Disuse osteoporosis. American Journal of Neuroradiology. 2010;31(7):1793-2001.

12. Yang H, Liu T, Zhou J, et al. Kyphoplasty versus vertebroplasty for painful osteoporotic vertebral compression fractures— which one is better? A systematic review and meta-analysis. Int J Spine Surg, 2013, 7: e45-57.

13. Ma XL, Xing D, Ma JX, et al. Balloon kyphoplasty versus percutaneous vertebroplasty in treating osteoporotic vertebral compression fracture: grading the evidence through a systematic review and meta-analysis. Eur Spine J, 2012, 21: 1844-1859.

14. Han S, Wan S, Ning L, et al. Percutaneous vertebral compression fractures: twelve-month follow-up in a prospective nonrandomized comparative study. Int Orthop, 2011, 35: 1349-1358.

15. Lee MJ, Dumonski M, Cahill P, et al. Percutaneous treatment of vertebral compression fractures: a meta-analysis of randomised and non-randomised controlled trials. Int Ortho, 2011, 35: 1349-1358.

16. Lee MJ, Dumonski M, Cahill P, et al. Percutaneous treatment of vertebral compression fractures: a meta-analysis of complications. Spine (Phila Pa 1976). 2009, 34: 1228-1238.

17. Xing D, Ma JX, Ma XL, et al. A meta-analysis of balloon kyphoplasty compared to percutaneous vertebroplasty for treating os- teoporotic vertebral compression fractures. Journal of clinical neuroscience : official journal of the Neurosurgical Society of Australasia. Jun 2013;20(6):795-803. Need to add one is better? A systematic review and meta-analysis. Int J Spine Surg, 2013, 7: e45-57.

18. Bozkurt M, Kahilogullari G, Ozdemir M, et al. Comparative analysis of vertebroplasty and kyphoplasty for osteoporotic vertebral compression fractures. Asian spine journal. Feb 2014;8(1):27-34.

19. Dohm M, Black CM, Dacre A, et al. A randomized trial comparing balloon ky- phoplasty and vertebroplasty for vertebral compression fractures due to osteoporosis. American Journal of Neuroradiology. 2014;35(2):222-227.

20. Dong R, Chen L, Tang T, et al. Pain reduction following vertebroplasty and kyphoplasty. International orthopaedics. 2013;37(1):83-88.

21. Dong R, Chen L, Gu Y, et al. Improvement in respiratory function after vertebro- plasty and kyphoplasty. International ortho- paedics. Dec 2009;33(6):1689-1694.

22. Grohs JG, Matzner M, Trieb K, Kepler P. Minimal invasive stabilization of osteoporotic vertebral fractures: A prospective non- randomized comparison of vertebroplasty and balloon kyphoplasty. Journal of Spinal Disorders and Techniques. 2005;18(3):238-242.

23. Hiwatsuki A, Westesson PLA, Yoshida T, et al. Kyphoplasty and vertebroplasty pro- duce the same degree of height restora- tion. American Journal of Neuroradiology. 2009;30(4):667-670.

24. Kong LD, Wang P, Wang LF, Shen Y, Shang ZK, Mening LC. Comparison of vertebroplasty and kyphoplasty in the treatment of osteoporotic vertebral compression fractures with intravertebral clefts. European Journal of Orthopaedic Surgery and Traumatology. 2014;24(SUPPL.1):S201-S208.

25. Kumar K, Nguyen R, Bishop S. A com- parative analysis of the results of vertebro- plasty and kyphoplasty in osteoporotic vertebral compression fractures. Neurosurgery. 2010;67(SUPPL.1):ONS171-ONS188.

26. Li X, Yang H, Tang T, Qian Z, Chen L, Zhang Z. Comparison of kyphoplasty and vertebroplasty for treatment of painful osteoporotic vertebral compression fractures: twelve-month follow-up in a prospective nonrandomized comparative study. Journal of spinal disorders & techniques. 2012;25(3):142-149.

27. Liu JT, Liao WJ, Tan WC, et al. Balloon kyphoplasty versus vertebroplasty for treat- ment of osteoporotic vertebral compression fractures: a meta-epidemiological study. Osteoporosis international: a journal established as result of cooperation between the European Foundation for Osteoporosis and the
Neurosurgery. 2009;52(5-6):233-237.

Minimally Invasive comparative prospective study of vertebroplasty on fresh compression fractures. A prospective non-randomised study on 154 patients. European Spine Journal. 2009;18(SUPPL. 1):S95-S101.

Vertebroplasty and kyphoplasty: Complementary techniques for the treatment of painful osteoporotic vertebral compression fractures. A review. 2013;17(39):6920-6925.

Effectiveness, security and height restoration on fresh compression fractures: a comparative prospective study of vertebroplasty and kyphoplasty. Minimally Invasive surgery. Sep 2010;130(9):1157-1166.

Analysis of clinical effects of percutaneous vertebroplasty and percutaneous kyphoplasty in treating osteoporotic vertebral compression fracture. Zhongguo gu shang [China] = China journal of orthopaedics and traumatology. May 2014;27(5):385-389.

Effect of vertebroplasty with bone filler device and comparison with balloon kyphoplasty. European Spine Journal. 2014;23(12):2718-2725.

Recompression in new levels after percutaneous vertebroplasty and kyphoplasty compared with conservative treatment. Archives of orthopaedic and trauma surgery. 2014;134(1):21-30.

Percutaneous vertebroplasty and kyphoplasty compared with conservative treatment. Archives of orthopaedic and trauma surgery. 2011;131(5):645-650.

Effect of cement volume on mechanical behavior. Spine. Jul 15 2001;26(14):1537-1541.

An ex vivo biomechanical evaluation of a hydroxyapatite cement for use with vertebroplasty. Spine. Jul 2013;38(13):1474-1478.

In not only vertebroplasty but also kyphoplasty, the resolution of vertebral deformities depends on vertebral mobility. American Journal of Neuroradiology. 2013;34(7):1474-1478.

Zhang C, Zhu K, Zhou J, et al. Influence on adjacent lumbar bone density after strengthening of T12, L1 segment vertebral osteoporotic compression fracture by percutaneous vertebroplasty and percutaneous kyphoplasty. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi [China] = Chinese journal of reparative and reconstructive surgery. Jul 2013;27(7):819-823.

Belkoff SM, Mathis JM, Jasper LE, Deramond H. The biomechanics of vertebroplasty. The effect of cement volume on mechanical behavior. Spine. Oct 2000;25(19):2580-2587.