

Systematic Review

Unilateral Versus Bilateral Balloon Kyphoplasty for Osteoporotic Vertebral Compression Fractures

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Background: Osteoporotic vertebral compression fractures (VCFs) commonly occur in aged people. Balloon kyphoplasty (KP) has been proven to be efficacious for pain relief and reduction of vertebral height for patients with osteoporotic VCFs. However, very little is known about the comparison of clinical and radiographic outcomes between unilateral and bilateral balloon KP in treating this kind of patients.

Objective: To compare the safety and long-term radiographic and clinical outcomes of unilateral or bilateral balloon KP to treat patients with osteoporotic VCFs.

Study Design: A systemic review and meta-analysis of all randomized controlled trials (RCTs) comparing the analgesic efficacy, radiographic outcomes, and complications between unilateral and bilateral balloon KP in patients with osteoporotic VCFs.

Setting: The MEDLINE, EMBASE, Pubmed, CINAHL databases, Bandolier, and the Cochrane Controlled Trials Register were systematically searched for evidence from their inception to July 2012 by 2 of the authors (J.L. and L.Z.).

Methods: Relevant reports were reviewed by 2 assessors independently and the reference lists of retrieved papers were scrutinized to identify further studies for inclusion, using guidelines set by PRISMA statement criteria.

Results: Three RCTs were enrolled in this study. The VAS scores showed no statistical difference between the groups before surgery and either at short-term or long-term follow-up. There was no statistical significance in polymethylmethacrylate (PMMA) leakage between the groups. Analysis of 2 studies showed statistical significance in surgery time (WMD -23.77 [-27.83, -19.71]; $P < 0.00001$) and PMMA (WMD -1.65 [-2.28, -1.02]; $P < 0.00001$) consumption between the groups.

Limitations: There were few data sources from which to extract abstracted data or published studies. There were only 3 RCTs that met criteria enrollment in this meta-analysis. The quality of these trials was quite low (Jadad score: 1-2). Variable reporting of end points and inconsistent definitions meant that we were not able to include every study for each outcome. There was also clinical heterogeneity among the studies.

Conclusion: The efficacy of both unilateral and bilateral balloon KP to provide rapid, significant, and sustained pain relief for patients with osteoporotic VCFs is validated. Unilateral balloon KP is a reasonable treatment for patients with osteoporotic VCFs considering that it could achieve equivalent pain relief with less surgery time and PMMA consumption compared to bilateral balloon KP. There was no evidence to prove that unilateral balloon KP results in higher incidence of PMMA leakage than bilateral balloon KP. Although unilateral balloon KP was less efficacious in the reduction of fractured vertebral body, it is still unclear if the clinical results of balloon KP were positively correlated with the restoration of vertebral height and amount.

Key words: Kyphoplasty, unilateral approach, bilateral approach, , postoperative pain, osteoporotic fractures

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Osteoporosis is the most common metabolic bone disease around the world. It's also the leading cause of vertebral compression fractures (VCFs), which can result in decreased mobility and quality of life (1-3). The primary treatment for osteoporotic VCFs consists of conservative methods including bed rest, analgesics, and early rehabilitation with a brace after symptomatic relief. However, a few patients may still complain of severe pain after conservative treatments and even show the progressive collapse of the vertebral body and kyphosis with or without neurological deficit (4). Balloon kyphoplasty (KP) is a minimally invasive surgical treatment for osteoporotic VCFs (5). The deformity is corrected by the insertion and expansion of an inflatable bone tamp (IBT) inside the fractured vertebral body. After reduction of the fractured bone, cement is deposited into the cavity created by the IBT to repair the fracture (6).

A few authors recommended unilateral KP for osteoporotic VCFs with bilateral treatment and the outcomes showed comparable satisfaction (7-9). The unilateral balloon KP offers the potential advantages of reducing the surgery time, cost, radiation exposure, and the risk associated with needle placement and polymethylmethacrylate (PMMA) leakage (6). Most previous studies have demonstrated equivalent analgesia to the bilateral balloon KP and an improvement in side-effect profile (4,6,10-13). However, the number of patients enrolled in each study was small and statistical significance was not reached across all variables and time periods measured. The aim of this study was to undertake a systematic review and meta-analysis of randomized trials comparing unilateral and bilateral approaches in patients with osteoporotic VCFs, including comparison of analgesic efficacy, technical details, radiographic outcomes, and complications.

METHODS

This is a systematic review of randomized trials comparing unilateral and bilateral approaches for patients with osteoporotic VCFs. The MEDLINE, EMBASE, Pubmed, CINAHL databases, Bandolier, and the Cochrane Controlled Trials Register were searched from their inception to July 2012 by 2 of the authors (J.L. and L.Z.). Prospective randomized trials were searched using the following combinations of terms: "kyphoplasty" and ("bilateral" OR "bi-lateral" OR "bipedicular" OR "bi-pedicular" OR "unilateral" OR "uni-lateral" OR "unipedicular" OR "uni-pedicular"). Language restrictions were not applied. The reference

lists of retrieved papers were scrutinized to identify further studies for inclusion. Reports were included if the study was a prospective study. Exclusion criteria were retrospective study, non-randomized controlled trial (RCT), short-term follow-up only. The studies were examined by 2 of the authors (J.L. and L.Z.) for measures that could be meaningfully compared between the studies. If data were not available in the original paper, the authors were contacted by email to request further information. The quality of individual trials was quantified using the Jadad scale (14) using 5 criteria: (i) randomization, (ii) description of randomization, (iii) blinding, (iv) adequacy of blinding, and (v) withdrawals documented.

Outcome measures included (i) analgesic efficacy, visual analogue dynamic pain scores (VAS) before surgery, short-term follow-up after surgery and final follow-up; (ii) surgery time and PMMA consumption; (iii) radiographic outcomes; (iv) complications, including PMMA leakage and adjacent vertebral fractures. All data were independently extracted and evaluated by 2 of the authors (J.L. and L.Z.) and differences were resolved by consensus.

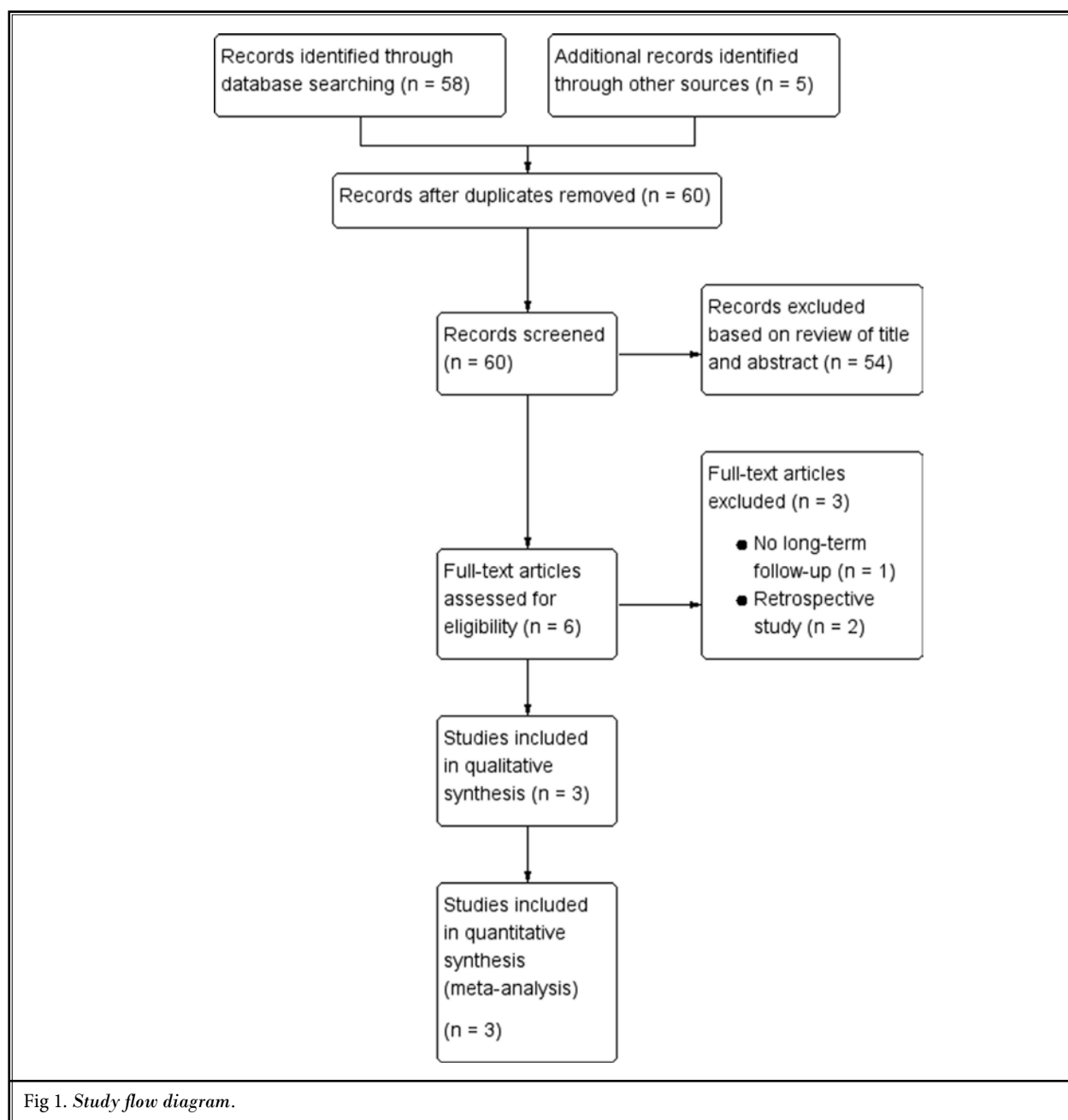
VAS scores were converted to a standardized 0 - 10 scale. Variables which were not reported numerically were estimated by manual measurements from the published figures.

Review Manager (RevMan for Windows version 5.1.4) was used for meta-analysis. The weighted mean difference and 95% confidence interval (CI) were used to estimate the overall pooled effect for numerical data in each study. The odds ratio and 95% CI were used to evaluate the dichotomous data. If heterogeneity was significant ($P \leq 0.05$), the random effects model was used. If heterogeneity was non-significant ($P > 0.05$), the fixed effects model was used. Those parameters which were unsuitable for meta-analysis or only reported in a single study were discussed in the text.

RESULTS

The 2 assessors (J.L. and L.Z.) agreed on the selection of 4 prospective RCTs relevant to our study (4,6,11,12). The main reasons for trial exclusion were illustrated in the PRISMA flow diagram (Fig 1). One short-term follow-up only RCT was excluded (12). Three prospective RCTs were finally enrolled in our study (4,6,11) (Table 1).

There were no large ($n \geq 1000$) randomized trials comparing unilateral and bilateral balloon KP. We identified 3 relevant studies so that the meta-analysis



included 151 patients. All of them had undergone balloon KP either by unilateral or bilateral approach. Fifty-two patients received KP under local anesthesia (4), and the other 99 patients under general anesthesia (6,11). One hundred and one patients enrolled in the 2 studies (4,6) received the operation in the acute to subacute phase, while the other 50 patients had the operation in the chronic phase (11).

All patients experienced excellent pain relief after surgery. The VAS scores showed no statistical difference between the groups before surgery and either at short-term or long-term follow-up (Figs. 2-4). The data of one study was unsuitable for meta-analysis because the authors did not disclose the standard deviation (SD) for VAS scores. Analysis of 2 studies showed statistical significance in surgery time (WMD -23.77 [-27.83, -19.71];

Table 1. Summary of randomized trials included in the meta-analysis. GA, general anaesthetic. OP, operation. PMMA, polymethylmethacrylate

Study/Country	Year	Jadad score	No. of patients	M/F ratio	Intraoperative	Follow-up	Summary of results
Chung, H J and colleges/Korea	2008	1	52	3 / 49	Local	27 months	OP in acute to subacute phase. Equivalent anesthetic efficacy. Less efficacious in reduction of kyphotic angle. Greater incidence of PMMA leakage.
Chen, L and colleges/China	2011	1	49	8 / 41	GA	71months	OP in acute to subacute phase. Equivalent anesthetic efficacy. Less OP time and PMMA consumption in unilateral group. No significant difference in reduction of kyphotic angle. Less incidence of PMMA leakage.
Chen, C and colleges/China	2011	2	50	0 / 50	GA	24 months	OP in chronic phase. Equivalent anesthetic efficacy. Less OP time and PMMA consumption in unilateral group. Less efficacious in reduction rate. Greater incidence of PMMA leakage.

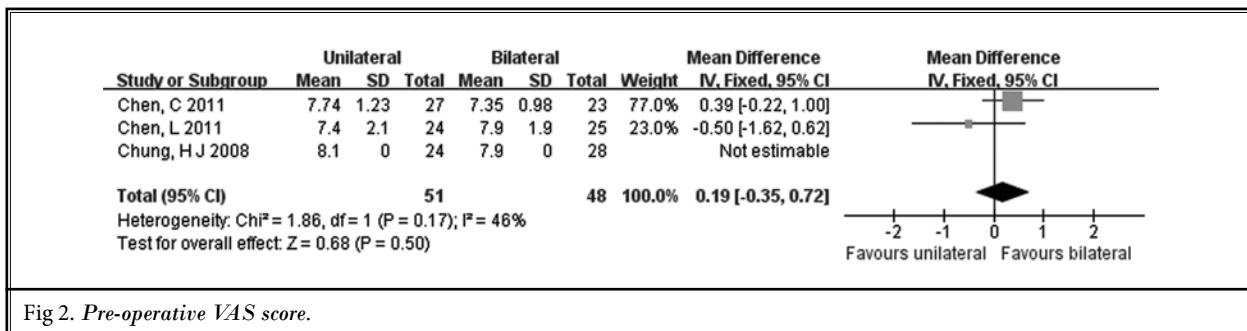


Fig 2. Pre-operative VAS score.

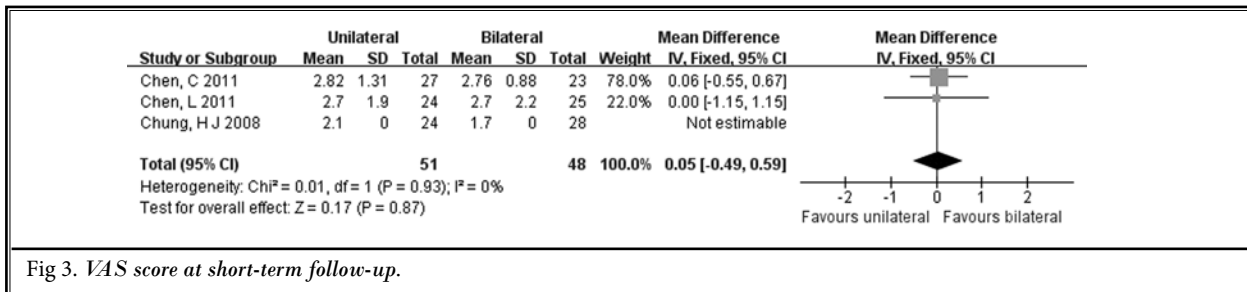


Fig 3. VAS score at short-term follow-up.

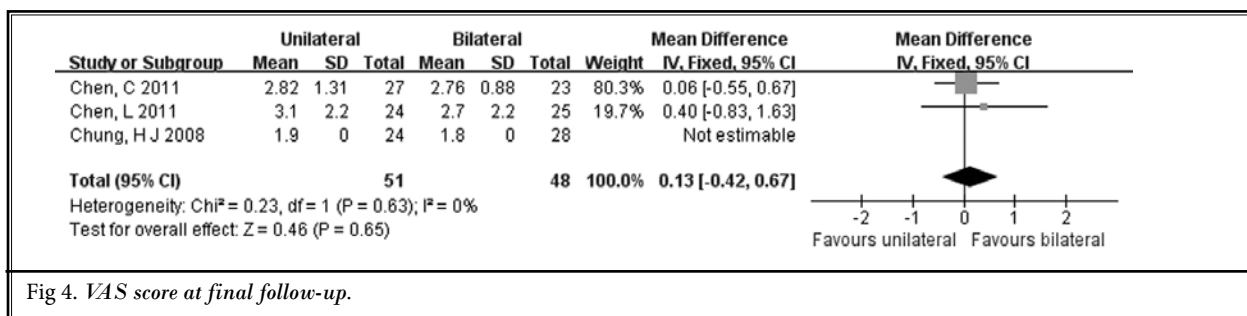


Fig 4. VAS score at final follow-up.

$P < 0.00001$) and PMMA (WMD -1.65 [-2.28, -1.02]; $P < 0.00001$) consumption between the groups (Figs. 5-6). There was no statistical significance in PMMA leakage between the groups (WMD 1.21 [0.39, 3.79], $P = 0.74$, Fig. 7).

Some parameters stated in the studies were unsuitable for meta-analysis, such as radiographic outcomes. Parameters for describing the radiographic outcomes stated in the studies were unsuitable for meta-analysis because they were different between 3 studies. One study used reduction rate of kyphotic angle to evaluate radiographic outcome (4), one study used vertebral height and kyphotic angle (6), and the other study used restoration rate ([restored vertebral height – ini-

tial fracture height]/adjacent normal vertebral height) (11). Although parameters were different, all 3 studies agreed that unilateral balloon KP was less efficacious in the reduction of the fractured vertebral body.

DISCUSSION

Over the past decades, vertebroplasty (VP) and balloon KP have been considered as the optimal treatments for osteoporotic VCFs because of the advantage of rapid pain relief and the stabilization of the vertebral bodies with fractures. Some have advocated balloon KP over VP (4,15).

The principal finding of this systematic review showed that both unilateral and bilateral balloon KP

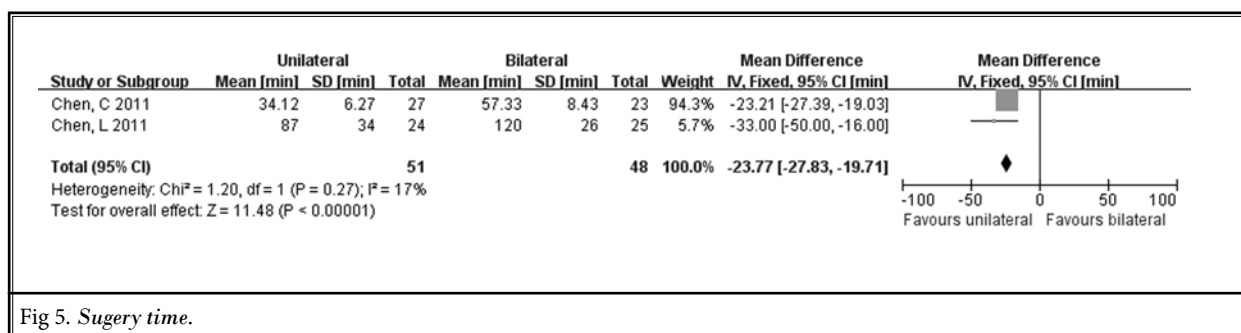


Fig 5. Surgery time.

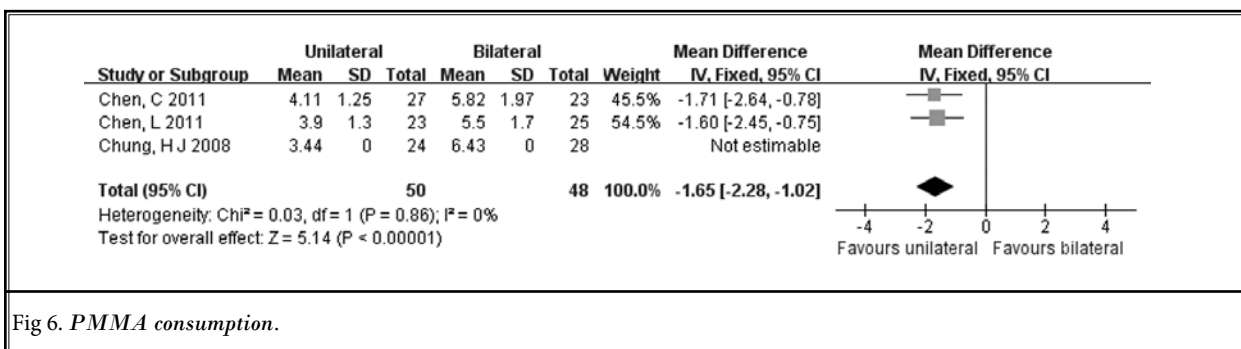


Fig 6. PMMA consumption.

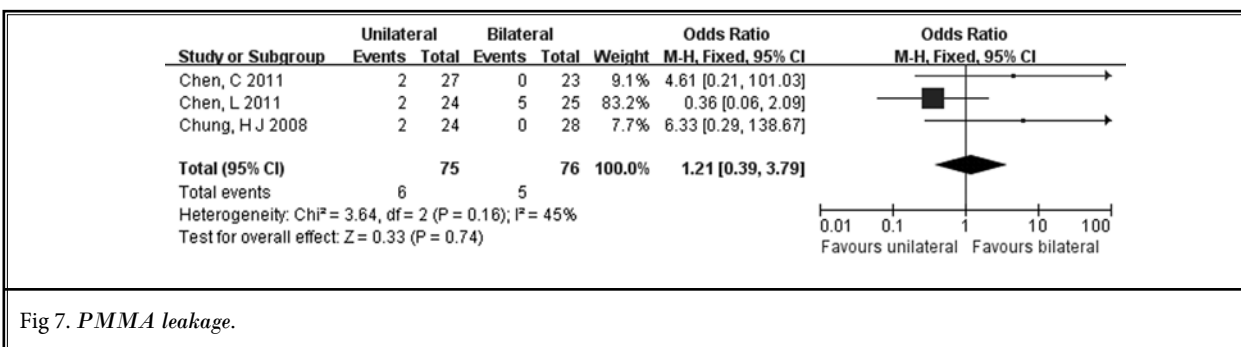


Fig 7. PMMA leakage.

provided rapid, significant, and sustainable improvements in pain. The results of our study showed that there was no statistical difference in VAS score between the groups before surgery and either at short-term or long-term follow-up. However, it still makes sense that unilateral balloon KP is a reasonable treatment for patients with osteoporotic VCFs considering that patients receiving unilateral balloon KP could achieve equivalent pain relief with less surgery time and PMMA consumption compared to patients receiving bilateral balloon KP.

Reduction of vertebral height and kyphosis is an important measure of radiographic outcomes after balloon KP. Although both groups gained significant vertebral height restoration, the results still indicated that unilateral balloon KP is less efficacious in the reduction of a fractured vertebral body despite that parameters for describing radiographic outcomes were unsuitable for meta-analysis. However, Steinmann et al (16) suggested that unilateral balloon KP showed comparable height restoration to the bilateral balloon KP. Furthermore, it has been reported that the clinical results of balloon KP were not always positively correlated with the restoration of vertebral height and amount of PMMA injected (17).

PMMA leakage, pulmonary edema, rib fractures, and adjacent vertebral fractures have been reported in balloon KP (4). The results showed that there was no significant difference in the incidence of PMMA leakage between the groups. None of the PMMA leakages had any apparent clinical consequences, and no patients developed neurological symptoms.

LIMITATIONS

There were few data sources from which to extract abstracted data or published studies. There were only 3 RCTs that met enrollment criteria for this meta-analysis. The quality of these trials was quite low (Jadad score: 1-2). Variable reporting of end points and inconsistent definitions meant that we were not able to include every study for each outcome, despite attempting to contact the authors. There was also clinical heterogeneity among the studies. Of 151 patients enrolled in this meta-analysis, 101 patients enrolled in 2 studies (4,6) received the operation in the acute to subacute phase, while the other 50 patients had the operation in the chronic phase (11). Fifty-two patients received KP under local anesthesia (4), while the other 99 patients received KP under general anesthesia (6,11).

CONCLUSION

In summary, this meta-analysis validates the efficacy of both unilateral and bilateral balloon KP to provide rapid, significant, and sustained pain relief for patients with osteoporotic VCFs. Unilateral balloon KP is a reasonable treatment for patients with osteoporotic VCFs considering that it could achieve equivalent pain relief with less surgery time and PMMA consumption compared to bilateral balloon KP. There was no statistical difference between the groups in the incidence of PMMA leakage. Although unilateral balloon KP was less efficacious in the reduction of the fractured vertebral body, it is still unclear if the clinical results of balloon KP were positively correlated with the restoration of vertebral height and amount.

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