Efficacy and safety of balloon kyphoplasty in the treatment of vertebral compression fractures: a systematic review

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CRD summary
The authors concluded that the use of balloon kyphoplasty to treat vertebral compression fractures can be effective and safe. However, the studies had methodological limitations and further research is required. There were limitations in the reporting of review methods but, overall, the authors’ cautious conclusions reflect the poor-quality evidence presented.

Authors' objectives
To evaluate the safety and efficacy of balloon kyphoplasty (BK) for the treatment of vertebral compression fractures (VCF).

Searching
MEDLINE, CINAHL, CC Search, SERLINE, the Cochrane Library, Science Citation Index Expanded, DARE, NHS EED and HTA were searched using the reported search terms. In addition, the reference lists of relevant studies were screened and the industry was contacted for unpublished studies. Proceedings of meetings or congresses were excluded. No language restrictions were applied.

Study selection
Study designs of evaluations included in the review
Experimental and observational studies with at least 10 patients were eligible for inclusion. The duration of follow-up in the included studies ranged from 3 to 24 months.

Specific interventions included in the review
Studies that evaluated BK were eligible for inclusion. Controlled studies could use any other medical or surgical treatment as the control. The included comparative studies compared BK with medical treatment or vertebroplasty. Most of the included studies used one procedure per patient.

Participants included in the review
Studies of patients with VCFs due to osteoporosis and/or tumour were eligible for inclusion. The majority of patients in the included studies were women aged over 65 years with a painful VCF secondary to osteoporosis and/or multiple myeloma between level T4 and L5. Where reported, the estimated age of the VCF ranged from less than 1 month to more than 18 months.

Outcomes assessed in the review
Studies that assessed any of the following primary review outcomes were eligible for inclusion: pain, vertebral height, kyphotic deformity, functional capacity, quality of life, cement material leakage, complications and the development of new vertebral fractures. Secondary review outcomes were use of health care resources (duration of hospital stay and the number of medical visits). The included studies did not always describe the measures used to assess outcomes.

How were decisions on the relevance of primary studies made?
Two reviewers independently selected the studies.

Assessment of study quality
Validity was assessed by considering the potential for selection bias (sample representative and consecutive enrolment), performance bias (cointerventions), detection bias (before-and-after analysis and blind/independent outcome assessment) and attrition bias (follow-up in at least 80% of patients). The authors did not state how the validity assessment was performed, or how many reviewers performed it.

Data extraction
The authors did not state how the data were extracted for the review, or how many reviewers performed the data extraction. Where required, standard deviations were estimated from published statistics.

Methods of synthesis
How were the studies combined?
Controlled studies and observational studies were discussed separately. Where possible and where studies used similar outcome measures, pooled odds ratios (ORs) or proportions and 95% confidence intervals (CIs) were calculated for dichotomous data and pooled weighted mean differences (WMDs) and 95% CIs for continuous data. Random-effects models were used.

How were differences between studies investigated?
Statistical heterogeneity was assessed using the chi-squared statistic. Meta-regression was used to examine potential reasons for heterogeneity (including age and aetiology of VCF and duration of follow-up).

Results of the review
Twenty-six studies (1,667 patients) were included. These comprised 3 prospective studies and 2 retrospective studies with control groups (211 patients at 237 levels) and 21 before-and-after observational studies (1,490 patients and 2,634 treated levels).

The main methodological flaws included: lack of a direct comparison of BK with vertebroplasty, poorly described inclusion criteria; heterogeneous populations; small sample sizes; inadequate description of concomitant treatments; lack of blinded or independent outcome assessment; use of non standardised and subjective or unknown outcome measures; lack of reporting and description of losses to follow-up; limited and variable duration of follow-up with high attrition; and poor reporting of the results.

Observational studies.

Pain (18 studies): after BK there was a significant reduction in pain measured on a visual analogue scale (VAS) post-operatively (WMD -5.11, 95% CI: -5.72, -4.49, p=0.000; based on 0 to 10 VAS scores from 11 studies) and at 1 year (WMD -6.10, 95% CI: -7.47, -4.48, p=0.000; based on 0 to 10 VAS scores from 5 studies) and 2 years (WMD -9.3, 95% CI: -10.65, -7.94, p=0.000; based on 0 to 20 VAS scores from 1 study), compared with baseline. Significant heterogeneity was found (p=0.07 and p=0.00); this was related to the duration of follow-up in the meta-regression.

Vertebral height: after BK there was a significant percentage increase in height at the anterior region (WMD 13.41, 95% CI: 10.9, 15.9, p=0.001; based on 4 studies), middle region (WMD 14.56, 95% CI: 12.4, 16.7, p=0.002; based on 3 studies) and posterior region (WMD 18.52, 95% CI: 9.7, 27.3, p=0.000; based on 2 studies), compared with baseline. Significant heterogeneity was found for all these analyses (p=0.001, p=0.002 and p=0.000 respectively; this was related to different ages of fractures in the meta-regression.

Kyphotic deformity: compared with baseline, there was a significant percentage reduction in Cobb's angle after BK (WMD -7.68, 95% CI: -9.34, -6.03, p=0.00; based on 7 studies). No significant heterogeneity was found.

Quality of life: compared with baseline, there was a significant improvement in quality of life measured on various subscales of the SF-36 questionnaire after BK (based on 4 studies; results presented graphically). The authors stated that considerable statistical heterogeneity was found (no data were presented).

Functional capacity: compared with baseline, there was a significant improvement in functional capacity measured on the Oswestry Disability Index after BK (WMD -23.8, 95% CI: -34.0, -13.55, p=0.00; based on 4 studies).

Comparative studies.

BK versus medical treatment: for patients who had received BK, there was a significant percentage reduction in pain intensity (WMD 55.6, 95% CI: 39, 72, p<0.001; based on 3 studies), a significant percentage increase in vertebral height at 6 months (WMD 20.3, 95% CI: 15.1, 25.5, p<0.001), and a significant reduction in Cobb's angle (angle remained almost constant in BK patients and increased in control; WMD -3.7 degrees, 95% CI: -6.48, -0.91, p<0.001;
based on 1 study) compared with patients receiving conventional medical treatment. There was a significant increase in mobility among patients receiving BK compared with conventional medical treatment (p=0.03), but no significant difference between treatments in quality of life (1 study).

BK versus vertebroplasty (1 study): there was no significant difference between BK and vertebroplasty in tumour VCFs for pain or functional improvement. For patients who had undergone BK, there was a significant increase in vertebral height (4.5 mm) and a significant improvement in local kyphosis (WMD -5.2, 95% CI: -9.71, -0.89, p=0.02) compared with patients who had undergone vertebroplasty.

Safety.

Leakage of filler material: cement leakage was reported in 7.13% (134 out of 1,742) levels treated with BK (based on 19 studies). Significant statistical heterogeneity was found, with greater incidence of leakage in studies including VCF of osteoporotic origin. Two comparative studies reported a reduced percentage of levels with leakage among patients undergoing BK compared with vertebroplasty (9% versus 0% and OR 0.04, 95% CI: 0.00, 0.68, respectively).

Major complications: among non-comparative studies, complications were reported in 2% of patients who had undergone BK and 1.16% of levels (based on 16 studies). Most of the complications were cardiopulmonary or neurological. Among patients who had undergone BK in comparative studies, 2 perforations of fractured lamina in 21 patients (1 study) and 9 out of 15 patients with difficulties in insertion or intolerance (1 study) were reported.

New vertebral fractures: among non-comparative studies, new vertebral fractures were reported in 16.5% of patients a year after they had undergone BK (based on 8 studies). Significant statistical heterogeneity was found (p=0.00). New vertebral fractures were significantly less common at 6 months among patients who had undergone BK compared with medical treatment (based on 2 studies).

Use of health services.

Hospital stay was reported to be significantly shorter in patients with BK compared with conventional medical treatment (WMD -10, 95% CI: -16.7, -3.3, p=0.003; 1 comparative study). In another comparative study, 6 months after BK the number of medical visits due to pain were significantly lower than in the control (8.6 versus 3.3 visits, p=0.01).

Authors' conclusions

Using BK to treat VCF can be effective and safe, but studies had methodological limitations and further research is required.

CRD commentary

The review addressed a clear question that was defined in terms of the participants, intervention and outcomes; the inclusion criteria for study design were broad. Many relevant sources were searched and attempts were made to minimise publication and language bias. Methods were used to minimise reviewer errors and bias in the selection of studies, but it was not clear whether similar steps were taken in the validity assessment and data extraction processes. Validity was assessed using specified criteria and the results of the assessment reported. Pooling clinically and statistically heterogeneous studies might not have been appropriate. However, some potential sources of heterogeneity were examined in a further analysis. Some studies treated more than one level per patient and this was apparently not taken into account in the analyses. There were limitations in the reporting of review methods but, overall, the authors' cautious conclusions reflect limited evidence from poor-quality and predominantly observational studies.

Implications of the review for practice and research

Practice: The authors did not state any implications for practice, except to recommend an adequate learning curve for trainee surgeons.

Research: The authors stated the need for good-quality prospective studies to evaluate the effects of BK on long-term objective and subjective outcomes (including vertebral height, reduction in kyphotic deformity, physiological, functional and psychological complications of VCF; lung function, survival, adverse events, treatment-related mortality...
and morbidity, rates of vertebral fracture adjacent to treated segment, costs of the procedure and cost-effectiveness) and prognostic factors associated with response to treatment. BK should also be compared with conventional treatments and other percutaneous interventions.

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