

# Effectiveness of Balloon Kyphoplasty in Patients with Painful Vertebral Compression Fractures

Cornelis Wilhelmus Jacobus van Tilburg<sup>1\*</sup>, Johannes George Groeneweg<sup>2</sup>, Dirk Leendert Stronks<sup>2</sup> and Frank Johannes Petrus Maria Huygen<sup>2</sup>

<sup>1</sup>Department of Pain Medicine and Anesthesiology, Pain and Neuromodulation Centre, Excellent Klinieken, Dordrecht, The Netherlands

<sup>2</sup>Center for Pain Medicine, Erasmus MC University Medical Center, Rotterdam, The Netherlands

\*Corresponding author: Cornelis Wilhelmus Jacobus van Tilburg, Department of Pain Medicine and Anesthesiology, Pain and Neuromodulation Centre, Excellent Klinieken, Dordrecht, The Netherlands, Tel: +31850410150; E-mail: [kvtilburg@excellentklinieken.nl](mailto:kvtilburg@excellentklinieken.nl)

Received date: May 19, 2018; Accepted date: May 25, 2018; Published date: June 1, 2018

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## Abstract

We performed a case series study on the effectiveness of balloon kyphoplasty (BKP) for painful vertebral compression fractures in 60 patients with acute axial lumbar and/or thoracic spinal pain due to osteoporosis, trauma or cancer, who were referred to the pain center of a general hospital. The pain intensity levels appeared to be statistically significant different between the pain level at baseline (T0) and the three moments of measurement (T1, T2, T3) after the procedure,  $p < 0.001$ . No statistically significant difference in Numerical Rating Scale (NRS) for pain was found between the three moments of measurement after the procedure. No statistically significant difference in NRS for pain was found between the patients with osteoporosis and those with cancer between T0 and T1 ( $p = 0.48$ ). This study shows that in patients with painful (non) malignant vertebral compression fractures BKP can result in a statistically and clinically significant pain reduction lasting at least one year. There is a need for new high quality studies to define the place of BKP in patients with acute axial back pain due to vertebral compression fractures.

**Keywords:** Balloon vertebroplasty; Vertebrogenic compression fracture; Osteoporotic fracture; Mechanical low back pain

## Introduction

Vertebral fractures often are very painful and lead to reduced quality of life and disability [1]. Common causes of vertebral fractures are osteoporosis (postmenopausal, secondary), trauma, primary tumors of the spine and metastasis. The worldwide burden of osteoporotic fractures in the year 2000 was estimated to be 9 million, among them 1.4 million clinical vertebral fractures [2]; about a third come to medical attention [3,4]. The incidence of osteoporotic clinical vertebral fractures in the Netherlands was estimated to be 0.7% in women and 0.2% in men aged 55 years or older [5]. Traumatic spinal fractures occur in 11.8 to 16.4 per 100000 populations (0.012-0.016%) [6,7]; the most common causes are a high-energy fall (39%, evenly distributed over the whole spine) and traffic accidents (26.5%, more fractures at the cervical and thoracic spine) [8]. The spine is also the most frequent site of bone metastasis. Spinal involvement may occur in up to 40% of patients with cancer and approximately 70% of patients with cancer have evidence of metastatic disease at the time of their deaths [9]. As many as 75% of vertebral metastases occur in patients with carcinoma of the breast, kidney, lung, prostate, thyroid and multiple myeloma [10,11].

Vertebral compression fractures occur in 55 to 70% of patients with multiple myeloma and are the initial clinical sign in 34 to 64% of these patients. Usual treatment for vertebral osteoporotic compression fractures consists out of analgesics, bed rest, casting and physical support. Other modalities were introduced depending on the clinical presentation and spinal level, aiming at the vertebra itself (e.g. radiotherapy, surgical approaches and/or cement augmentation). Cement augmentation evolved into a percutaneous technique, injecting cement into the fractured vertebral body. Balloon

kyphoplasty (BKP) seems to be a safe, minimally invasive procedure for the treatment of painful vertebral fractures, which is intended to reduce pain and disability and correct vertebral body deformity using balloons [12-18]. Studies have demonstrated that cement augmentation procedures provide better clinical outcome compared to non-surgical management [19]. When comparing BKP with vertebroplasty (VP), the first proved to have better results, which are maintained over long-term follow-up [20-23], with less side effects such as cement leakage [24]. In patients with cancer, BKP proved to be an effective and safe treatment that rapidly reduces pain and improves function [25-31]; a biopsy can routinely be performed [32]. Comparing to surgery, percutaneous cement treatment predicts significantly reduced costs as well as length of stay [33,34]. The use of BKP or VP in the management of vertebral compression fractures in patients with cancer may be a cost-effective strategy [35].

In 2009, two articles appeared in the New England Journal of Medicine, reporting that improvements made in pain (and pain related disability) by VP in patients with painful vertebral osteoporotic compression fractures were similar in the treatment group and the sham group [36,37]. The results of these trials seem to be in disagreement with the accumulated literature on this subject [38]. In one study [36], MRIs and/or bone scans were not required if the fracture was known and under one year of age. The targeted level was 250 patients, but only 131 subjects were enrolled. Eight patients (12%) in the vertebroplasty group crossed over to the sham group, while 27 (43%) of patients in the sham group crossed over to the vertebroplasty group. In the other study [38], out of 219 eligible patients, only 78 (36%) were enrolled. While being a multicenter trial, more than 67% of the patients came from a single site. The mean volume injected into the vertebrae was (only) 2.8 mL. A meta-analysis of the individual patient data in the two randomized placebo controlled trials (RCTs) failed to show an advantage of VP over placebo [39]. More discussion regarding

the differences between placebo efficacy and specific efficacy was provided in another article by Miller, Kallmes and Buchbinder [40].

Complications associated with BKP are attributed to the technique itself (e.g. cement leakage, infection) and/or cardiopulmonary events (e.g. cement, fat, bone marrow or air embolisation). These major complications are rarely seen, but may warrant a high level of suspicion and immediate action, e.g. early surgical intervention and/or pharmacological treatment [41-47]. This case series study reports on pain reduction after BKP in patients with painful vertebral compression fractures due to osteoporosis, trauma or cancer, who were referred to the pain center of a general hospital. All BKP procedures were performed by experienced interventional pain physicians.

## Materials and Methods

We performed a case series study on the effectiveness of BKP for painful vertebral compression fractures in 60 patients with acute axial lumbar and/or thoracic spinal pain. Patients were referred to the pain center of a general hospital with complaints of acute axial pain on lumbar and/or thoracic level. These patients were managed according to the flowchart presented in Figure 1. When a painful vertebral compression fracture was suspected (Table 1) and patients satisfied to the indications and contra-indications (Table 2), they were eligible for BKP. Each patient received a brochure explaining the complete procedure. After obtaining written informed consent for the procedure patients were scheduled for BKP.

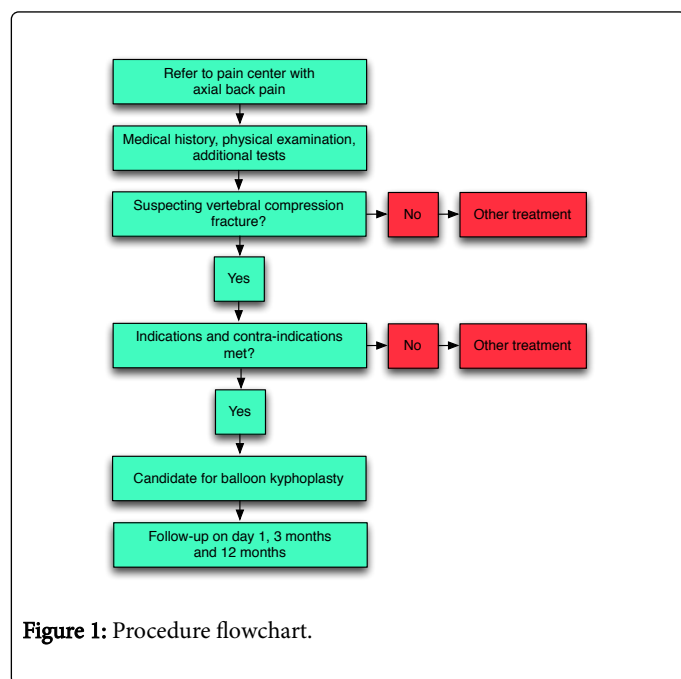


Figure 1: Procedure flowchart.

Monitoring of vital parameters took place according to the American Society of Anesthesiologists [48] House of Delegates Standards for Basic Anesthetic Monitoring (ASA). Antibiotic prophylaxis was provided with Cephazolin 2 g. Continuous Oxygen 15 L/min through a non-rebreather mask and bag was applied and patients were placed in the prone position using pillows under the chest and pelvic area. Continuous sedation with intravenous (IV) propofol Target Controlled Infusion (TCI) 0.5 µg/mL and continuous analgesia with IV remifentanyl 0.05 µg/kg/min was used. Doses were titrated to a Ramsay score of 4 out of 6 [49]. Continuous IV sedation

and analgesia was provided to the patient by a nurse anaesthetist with subsequent training in sedation.

Medical history
1. Acute (deep) spinal pain episode
2. Trauma
3. Most comfortable when motionless
4. Osteoporosis
5. Cancer
6. Previous vertebral compression fracture(s)
7. Persistent pain after acute pain episode subsided
8. Abdominal symptoms (early satiety, abdominal bloating)
9. Anorexia and subsequent weight loss
10. Lower rib syndrome
11. Inactive, sedentary lifestyle
12. Fear of falling
13. Sleep pattern disturbed (due to pain and inactivity)
14. Depression
Physical examination
1. Tenderness to deep palpation and percussion over the affected vertebra
2. Para spinal muscle spasm
3. Short thoracic spine, kyphosis
4. Decreased pulmonary function (restrictive lung disease and reduced vital capacity)
Additional tests
1. Lateral X-ray of spine
2. MRI

Table 1: Medical history, physical examination and additional tests used in establishing the diagnosis of painful vertebral compression fractures.

Indications
1. Medical history, physical examination and additional tests suggestive of painful vertebral compression fracture on lumbar and/or thoracic level
2. Vertebral edema present on MRI
3. Numerical Rating Scale equal to or higher than 4/10
4. Preoperative anesthetic screening warrants the use of continuous IV sedation and analgesia
Contra-indications
1. Active infection
2. Progressive neurological deficits
3. Major psychiatric disorder (according to psychiatrists opinion)
4. Anticoagulation cannot be stopped
5. Allergies to any medication or cement
6. Pregnancy
7. Contra-indication for MRI

Table 2: Indications and contra-indications for balloon kyphoplasty.

Skin and periosteal infiltration was performed at each side with Lidocaine 2%. Under fluoroscopic guidance, a bilateral trans- or

extrapedicular approach was used with introducer tools and inflatable balloon-like devices, polymethylmethacrylate (PMMA) bone cement and delivery devices (Kyphon inc./Medtronic Spine LLC, 1221 Crossman Ave, Sunnyvale, CA 94089, United States of America). During each procedure, a biopsy was taken and a combination of Paracetamol 1 g IV, Dynastat 40 mg IV and Morphine 0.1 mg/kg IV was given for immediate postoperative pain management. Wound edges were infiltrated with Ropivacaine 0.2%.

The main outcome parameter was pain reduction (Numerical Rating Scale (NRS) for pain) [50-55]. The 0-10 verbal NRS for pain is a tool that enjoys widespread clinical use due to its ease of administration. While using the NRS for pain, patients are asked to rate their pain on a scale from 0 to 10, where 0 represents "no pain" and 10 represents "the worst pain possible," using whole numbers (11 integers including zero). Often the value of "4" is used to confirm clinical nursing judgment as to the need for further intervention or documentation that the patient's goals for analgesia have been achieved. The NRS for pain was measured preoperatively (T0) and during follow-up.

Time periods for follow-up were on the first postoperative day (T1), at 3 months (T2) and at 12 months (T3). Descriptive statistics were used to determine the frequencies of the demographic and the outcome parameters. Differences in pain level between baseline (preoperative, T0) and postoperative (T1, T2 and T3) time periods were analyzed using the related-samples Friedman's Two-Way Analysis of Variance by Ranks. Post-hoc pairwise comparisons were performed with the Related Samples Wilcoxon Signed Rank Test, using a Bonferroni correction to counteract the problem of multiple comparisons. The independent-samples Mann-Whitney U test was used to study the hypothesis that the distribution of the NRS for pain scores (T0-T1) is the same in the patients with osteoporosis and those with cancer. Data were analyzed using SPSS for Mac, version 22 (International Business Machines (IBM) Corporation, Software Group, Route 100, Somers, NY, 10589, United States of America).

## Results

Sixty patients were treated with BKP for painful vertebral compression fractures and had follow-up for 1 year. The procedure is presented in Figure 2. Demographic data are presented in Table 3. Using the Kolmogorov-Smirnov test, the distributions of these parameters appeared to be skewed. Therefore, central tendency and dispersion of the distributions are reported as median and interquartile range (IQR). Vertebral fracture levels are presented in Figure 3. Most fractures occurred at the Th12-L1 region. The pain intensity levels appeared to be statistically significant different between the pain level at baseline (T0) and the three moments of measurement after the procedure,  $p < 0.001$  (Figure 4). No statistically significant difference was found between the three moments of measurement after the procedure. Results of the pairwise comparisons are presented in Table 4.

In 40 patients, a painful vertebral compression fracture was present due to osteoporosis, in three patients due to trauma and in 17 patients due to cancer (five patients with multiple myeloma, six with metastatic lung cancer, two with metastatic breast cancer, two with metastatic prostate cancer, one with metastatic ovary cancer and one with metastatic cervix cancer). No statistically significant difference in NRS for pain was found between the patients with osteoporosis and those with cancer between T0 and T1 ( $p = 0.48$ ).

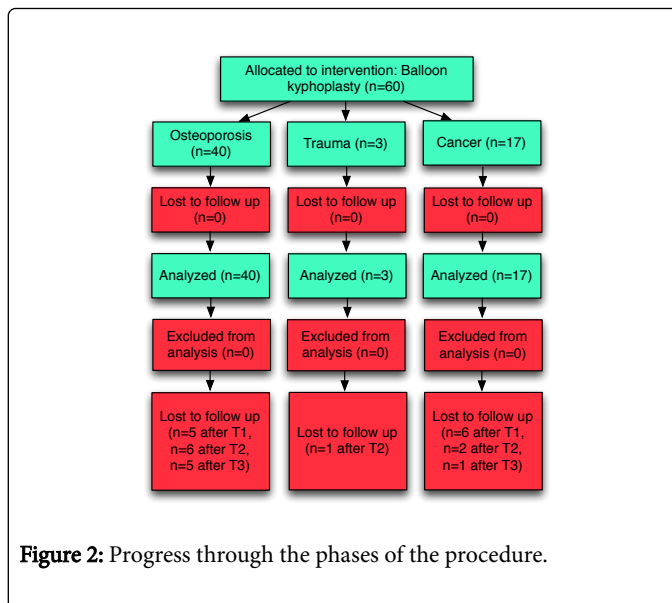


Figure 2: Progress through the phases of the procedure.

Group	N (F, %)	Age		BMI	
		Median	IQR (Q3-Q1)	Median	IQR (Q3-Q1)
Osteoporosis	40 (28, 70)	77	16	26	7.3
Trauma	3 (2, 66.7)	59	N/A	27.9	N/A
Cancer	17 (10, 58.8)	71	11	22.8	10.3

Table 3: Demographic data of the patients (100% Caucasian) in the study (IQR: Interquartile range; N: number of patients; F: Female).

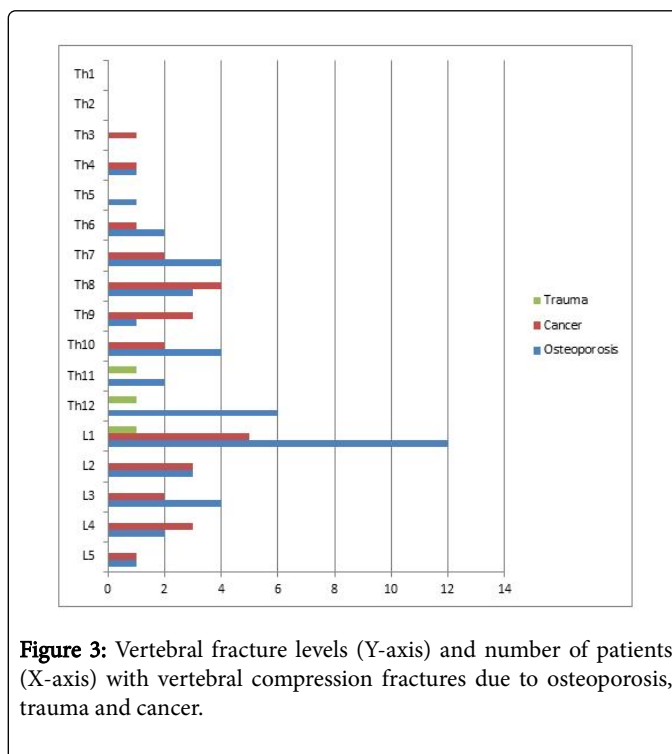
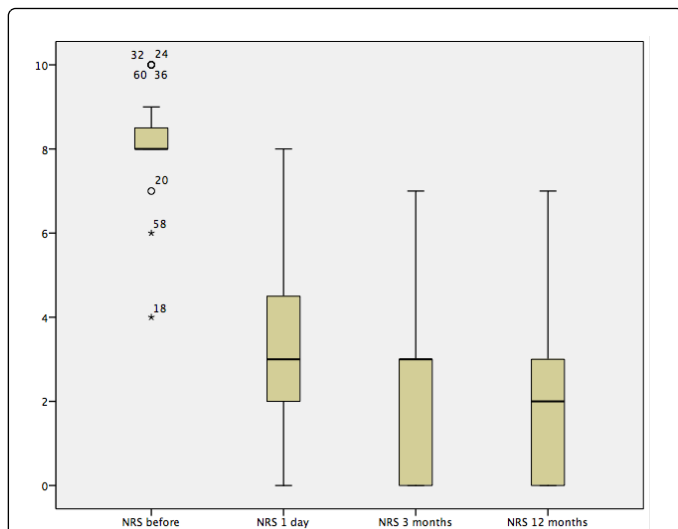


Figure 3: Vertebral fracture levels (Y-axis) and number of patients (X-axis) with vertebral compression fractures due to osteoporosis, trauma and cancer.



**Figure 4:** Boxplot of the pain intensity before vertebral augmentation (NRS before), first postoperative day (NRS 1 day), at 3 months (NRS 3 months) and at 12 months (NRS 12 months) in patients with painful vertebral compression fractures due to osteoporosis, trauma or cancer.

	T0	T1	T2
T0			
T1	<0.001		
T2	<0.001	0.41	
T3	<0.001	0.12	0.43

**Table 4:** Results (P-value) of the pairwise comparisons between the moments of measurement, using a Bonferroni correction ( $\alpha=0.08$ ) (T0=before the BKP procedure; T1=first postoperative day; T2=3 months after treatment; T3=12 months after treatment).

In the patients with cancer, one patient died after one day, another ten within one month and another two within three months. In the patients with osteoporosis, one patient died within one month and another one within three months. In the patients with traumatic vertebral compression fracture, no one died within the follow-up period of 1 year. No major complications occurred as a direct result from the BKP procedure.

## Discussion

In this case series study, we measured the pre- and postoperative (until at least one year after operation) pain levels in 60 patients with painful vertebral compression fractures on lumbar and/or thoracic level due to osteoporosis, trauma or cancer, who were treated with BKP. The pain intensity levels appeared to be statistically significant different between the pain level at baseline and the three moments of measurement after the procedure. No statistically significant difference was found between the three moments of measurement after the procedure. No statistically significant difference in pain intensity was found between the patients with osteoporosis and those with cancer

between baseline and the first postoperative day. One patient with cancer died within 1 day after the BKP procedure; the exact cause of death is unknown, more specifically a possible contribution to this death from the BKP procedure and/or the IV sedation.

In support of the recently published papers advocating the use of BKP for painful vertebral compression fractures in recent years, and contrary to two papers reporting no statistically significant difference of vertebroplasty compared to a sham control group, our case series study indicates that BKP can result in a statistically significant and sustained pain reduction during 1 year follow-up. This case series study has several limitations: 1) We didn't include experimental control, and therefore cannot compare the treatment results with a control group, e.g. a placebo procedure; 2) Pain scores were measured during specific moments in time; we don't know if using pain scores reflecting certain periods of time might lead to a different result; 3) Due to morbidity and mortality predominantly occurring in the group of patients with cancer, the number of missing data increased as time progressed.

## Conclusion

This case series study shows that in patients with painful (non) malignant vertebral compression fractures BKP can result in a statistically and clinically significant pain reduction lasting at least one year. There is a need for new high quality studies to define the place of BKP in patients with acute axial back pain due to vertebral compression fractures.

## Acknowledgements

The author wishes to thank Bravis hospital, Bergen op Zoom, The Netherlands, for its policy of tolerance (at the moment vertebral augmentation procedures are not reimbursed in the Netherlands) and Fleur A. Schuurmans, RN for her work in partly collecting the data. This manuscript also serves as part of the PhD thesis of the first author on minimally invasive for lumbar spine related pain disorders.

## Competing interests

All authors declare that no support from any organisation for the submitted work has been received, no financial relationships with any organisations have been established that might have an interest in the submitted work and no other relationships or activities were established that could appear to have influenced the submitted work.

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