



Review Article

# A Comparison of Kyphoplasty, Vertebroplasty, or Non-Surgical Treatment of Traumatic/Atraumatic Osteoporotic Vertebral Compression Fractures: A Short Review

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## ABSTRACT

**Background:** Although the majority of patients with traumatic/atraumatic osteoporotic vertebral compression fractures (OVCFs) may be managed with non-surgical treatment (NST), a subset (e.g. 40%) with significant pain, loss of vertebral height, and other factors may warrant percutaneous vertebroplasty (V), or percutaneous kyphoplasty (K).

**Methods:** We compared the impact of these three treatment modalities, V, K, or NST, for managing OVCFs.

**Results:** In several studies, both V and K resulted in comparable improvement in pain relief, postoperative kyphotic angles, increased anterior vertebral heights, and frequency of leakage of bone cement. One study evaluating 16 RCT's (Randomized Controlled Studies), however, observed K significantly; "decreased the kyphotic wedge angle, increased the postoperative vertebral body height, and decreased the risk of cement leakage vs. V". Further, in some series, both V and K resulted in higher quality of life scores and better pain relief vs. NST, while other studies showed V was superior to K. Further, although the risk of adjacent level fractures (ALF) following V, K, and NST were comparable in most studies, one clearly demonstrated NST had the lowest incidence of ALF. Despite all these findings, most studies concluded outcomes were comparable for all 3 groups.

**Conclusions:** Although most OVCFs are still managed with non-surgical treatment (NST), a subset (e.g. about 40%) may warrant V or K. Although both V and K have been shown to result in significantly better pain relief, higher quality of life scores, increased postoperative vertebral body height compared with NST, outcomes for all 3 groups remained the same.

**Keywords:** Kyphoplasty, vertebroplasty, conservative management, osteoporotic, compression fractures, optimal treatment

## INTRODUCTION

Traumatic/atraumatic osteoporotic vertebral compression fractures (OVCFs) attributed to osteoporosis cost the US health care industry over \$1 billion dollars/year. Although the majority of OVCFs may be managed with non-surgical treatment (NST), a subset (e.g. 40%) with significant loss of vertebral height, pain, and other factors may warrant percutaneous kyphoplasty (K) or percutaneous vertebroplasty (V).<sup>[3]</sup>

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Here we provide a short perspective reviewing the pros and cons for these 3 treatment options for managing traumatic/atraumatic OVCFs.<sup>[1-13]</sup>

### Frequency of Traumatic Osteoporotic Vertebral Compression Fractures (OVCFs)

Goldstein *et al.* in 2015 observed that vertebral compression fractures (VCFs) most commonly were attributed to osteoporosis [Table 1].<sup>[3]</sup> The medical costs approached nearly \$1 billion per year in the United States. Further, up to 40% may exhibited persistent pain within the first year along with other complaints/symptoms/signs warranting consideration of percutaneous vertebroplasty (V) or percutaneous kyphoplasty (K) rather than non-surgical treatment (NST).

### Different Conclusions Regarding the Impact of V vs. K on Kyphotic Angles, Vertebral Body Heights and Risks of Cement Leakage

Two 2018 studies came to different conclusions regarding the relative impact of V vs. K on post-procedural; kyphotic angles, vertebral body heights, and risks of cement leakage. Wang *et al.* in 2018 radiographically evaluated the outcomes for 57 patients over a 2-year period undergoing V (31 patients) vs. K (26 patients) for OVCFs [Table 1].<sup>[10]</sup> Of interest, the V procedures required an average of 29.6 minutes, significantly shorter than the 37.4 minutes required to perform K. The postoperative kyphotic angles and anterior vertebral heights showed more improvement with V vs. K, but both groups exhibited similar frequencies of leakage of bone cement. Reviewing 16 RCTs in 2018, Wang *et al.* compared the relative safety/efficacy of V vs. K for treating OVCFs [Table 1].<sup>[9]</sup> They alternatively concluded that K significantly: “decreased the kyphotic wedge angle, increased the postoperative vertebral body height, and decreased the risk of cement leakage vs. vertebroplasty”. Also, in 2018, Beall *et al.* found no significant differences between K and V for anterior or posterior vertebral height preservation, but observed K resulted in greater height restoration vs. V [Table 1].<sup>[11]</sup>

### Similar Risks of Adjacent Level Fractures (ALF) After V, K, and NST With One Exception

Multiple studies looked at whether V, K, or NST correlated with higher rates of adjacent level fractures (ALF). In a meta-analysis in 2017, Zhang *et al.* identified 12 studies (5 randomized clinical trials (RCT); 7 prospective studies) that involved 1,328 patients; 768 underwent V/K with PMMA (polymethylmethacrylate) vs. 560 treated non-surgically (NST) [Table 1].<sup>[12]</sup> They found no increased risk of ALF following V/K or NST. Similarly, when Marcia *et al.* in 2018 evaluated V and K for 33 patients from 7 systematic reviews, 6 cohort studies, 15 randomized clinical trials, and 5 international guidelines, they too found patients demonstrated comparable frequencies

of ALF utilizing all 3 procedures [Table 1].<sup>[7]</sup> When Wang *et al.* in 2018 evaluated outcomes for 57 patients over a 2-year period following V (31 patients) vs. K (26 patients) procedures for OVCFs, they too observed comparable frequencies of ALF following V vs. K. [Table 1].<sup>[10]</sup> Beall *et al.* in 2018 confirmed similar findings [Table 1].<sup>[11]</sup> Alternatively, when Zhu *et al.* in 2019 evaluated 15 studies focusing on the treatment of OVCFs, they found K resulted in the greatest reduction of re-fractures at the initial level, while also reducing the risk of subsequent ALF vs. V, while NST most effectively reduced subsequent ALF [Table 1].<sup>[13]</sup>

### Similar or Better Pain Relief with V vs. K, With Both Typically Superior to NST

Several studies showed similar or better pain relief with V or K, with both procedures proving superior to NST [Table 1]. Yuan *et al.* in 2016 identified 10 randomized controlled trials (RCT) involving 626 patients treated with K/V vs. 628 undergoing NST [Table 1].<sup>[11]</sup> Patients averaged 64 to 80 years of age respectively in the two groups, and most were female. V/K both resulted in more pain relief and higher quality of life compared to those treated with NST. Interestingly, 8 vertebroplasty studies and 2 kyphoplasty reports demonstrated that better pain relief was achieved with V compared with K. Marcia *et al.* (2018) found V and K both offered effective pain control, improved function, and a better quality of life vs. NST [Table 1].<sup>[7]</sup> Similarly, when Wang *et al.* (2018) looked at 57 patients over a 2-year period undergoing V (31 patients) vs. K (26 patients) procedures for OVCFs, they found that at one postoperative day, VAS scores and Oswestry Disability Index (ODI) scores were comparably better in both groups [Table 1].<sup>[10]</sup> In 2018, Beall *et al.* compared V, K, vertebral body stents (VAI), and NST for treating thoraco-lumbar OVCFs (e.g. minimum of 20 patients/study) [Table 1].<sup>[11]</sup> Although Visual Analog Scale (VAS) pain reduction was comparable for 3 procedures, V, K, and NST, they did note that Oswestry Disability Index (ODI) scores were better for K vs. VAI. Further, Zhu *et al.* (evaluated 15 studies) found V and K were comparably effective for pain control in OVCFs, while Wang *et al.* (2018 - 16 RCTs) noted similar outcomes and the same VAS/ODI for V and K [Table 1].<sup>[9,13]</sup>

### Shift from V to K for Treating OVCFs in the Medicare Population (2005-2015) Reflected Changes in Reimbursement

Utilizing the Centers for Medicare and Medicaid Services annual Medicare Physician Supplier Procedure Summary database, Rabej *et al.* (2019) retrospectively evaluated Medicare data (2005-2015) regarding the impact of decreased reimbursement rates for V and increased reimbursement for K for OVCFs [Table 1].<sup>[8]</sup> From 2005 to 2015, the incidence of K over V increased by 18.3% (48,725 to 57,646), largely reflecting the increased reimbursement rates for K. Additionally, changes in reimbursement rates also shifted many to “office-based procedures (\$728.50/yr., P<0.001, R=0.69)” rather than in-hospital settings. Of interest, although most procedures were originally performed by radiology, surgery, and anesthesia/

**Table 1:** Studies Utilizing Vertebroplasty (V), Kyphoplasty (K), Vs. Non-Surgical Treatment (Nst) For Traumatic/Atraumatic Osteoporotic Compression Fractures.

Author Year	Type of study	Type of procedure for OVCFs	Results	Results	Conclusions
Yuan 2016	10 RCTs 626 V/K 628 CG/NST	Hypothesis V/K > Pain Relief and Improved ADL vs CG/NST	8 V studies 2 K studies Ages 64-80	V and K > Pain Relief and Quality life vs. CG/NST	Better pain relief with V > K vs. CG/NST
Zhang 2017	1328 Pts 12 Studies 5 RCT, 7 PS	768 PMMA V/K vs 560 CG/NST	Equal ALF for V/K vs. CG/NST	Same BMD in all groups	Same Number ALF K/V vs. CG/NST
Beall 2018	25 Studies level I/II PS: K, V, VAI, NST 20 Pts/study	K Trend > Pain Reduction vs V, NST V Equal Pain Reduction to NST	K > Pain Control Disability vs VAI	K > V Height Restoration Equal Fracture Rates K vs. V vs. NST	ODI more reduced for K vs. VAI K and V Equal Vertebral Height Preserved/Restored
Kurra 2018	Mortality Rates for OVCFs	Hypothesis: K Lowered Mortality Rates vs. V and NST	=Mortality Rates K, V, NST	K Did not Lower Mortality Rates	K, V, NST Same Mortality Rates
Wang 2018	16 RCT K vs. V	K Significant Decreased Kyphotic Angle vs. V	K > Postop Vertebral Height vs V	K < Risk Cement Leakage vs V	Same Outcomes K and V on VAS and ODI
Wang 2018	Safety/efficacy V and K for OVCFs	57 Patients >21 years old V-31 Pts; K-26 Pts	OR Time V-29.6 min K-37.4 min	1 Day Postop VAS and ODI Equal V+K	V and K Similar Leakage of Bone Cement and ASF
Lis 2018	CSA with K Before SRS for MD	CSA Prior to K on MR vs. Post K Myelo-CT -Plan SRS for MD	30 Patients 41 Levels	23.4% (10/41) < Decreased CSA	20% (8/41) Epidural Extravasation PMMA; 1/10 < CSA
Choo 2018	ACS-NSQUIP Database 2433 Patients V-242 (9.9%) K-2191((0.1%)	Preoperative Risk Factors For 30-Day Complications Mortality	Risk Factors- Complications Dependent Sepsis, MD Infection, In-patient	Risk factors- Mortality Health Status, Dialysis, MD Steroids In-patient	Preoperative Risk Factors for 30-Day Complications and Mortality for Both V and K Included: MD, In-patient
Marcia 2018	Literature Review K and V Pain Control	> Quality Life Safety/Efficacy	33 Studies: 7 Systemic Reviews	6 Cohort Studies 15 RCTs 5 International guidelines	V and K Safe and Effective; No Increase in Post Treatment Factures-ALF
Lee 2018	Risks Recur OVCFs after V, K, NST for OVCFs	46/132 (34.8%) New OVCFs V, K	Major Risk Factors: Age > 70 Low BMD	Major Risk Factors: Cement Augmentation	Major Risk Factors Failure to take Osteoporosis Medications
Zhu 2019	V, K, vs. NST for OVCFs 15 Studies	K Reduced Risks vs. V for Subsequent fracture/Refracture	NST – Least ALF	V and K Comparable Pain Control	Same Outcomes V, K, NST
Rabei 2019	Rates of V vs. K from 2005-2015	Centers Medicare/ Medicaid Services... Database Radiology Performed 71% 2005;43% 2015	Highest 2008 108.11% Decline to 15.56% 2009	Decreased Reimbursement V by 61.7%: 2005 (\$35,409) 2015(\$13,478)	K Reimbursement Increased 2005 (\$48,725) 2015 (\$57,646) More outpatient office locations

V=Vertebroplasty, K=Kyphoplasty, PMMA=Polymethylmethacrylate, Rx=Treatment, sig.=Significant, Cons=Conservative, O.R.=Operating Room, ASD=Adjacent Segment Disease, ALF=Adjacent Level Fractures, Disease, NST=Non-Surgical Treatment, OVCFs=Osteoporotic Vertebral Compression Fractures, SRS=Stereotactic Radiosurgery, VAI=Vertebral Body Stents/Implants, VAS=Visual Analog Scale, ODI=Oswestry Disability Index, ACS=American College of Surgeons, RCTs=Randomized Controlled Trials, ADL=Activities of Daily Living, Rx=Treatment, Cons=Conservative, BMD=Bone Mineral Density, Pts=Patients, vs=Versus, CG=Control Group, NST=Non-Surgical Treatment, PS=Prospective Studies, Postop=Postoperative, MR=Magnetic Resonance Imaging, Myelo-CT=Myelogram CT Study, MD=Metastatic Disease, CSA=Cross Sectional Area

pain medicine (i.e. in descending order), more cases shifted over time out of the hands of radiology to the other providers; in short, radiology performed 71% of these procedures (V/K) in 2005, but this number was reduced to 43% by 2015.

### Thecal Sac Area After K for Pathological/Metastatic OVCFs Prior to Stereotactic Radiosurgery (SRS)

Lis *et al.* in 2018 assessed changes in the cross-sectional thecal sac volume after K but prior to single-fraction stereotactic radiosurgery for symptomatic vertebral compression fractures due to metastatic disease [Table 1].<sup>[6]</sup> They compared pre-kyphoplasty MR with post kyphoplasty Myelo CT studies (i.e. prior to performing SRS for treatment of metastatic disease). They specifically looked at; cross-sectional dural volume, epidural displacement, volume/location of tumor, extrusion of polymethylmethacrylate (PMMA) into the canal, fracture progression, and/or fracture reduction. For 30 consecutive patients, 41 levels were treated with K; 24% (10/41) showed a decreased thecal sac volume, decreased presence of epidural disease, and decreased bony destruction through the posterior vertebral cortex without fragment extrusion into the spinal canal. Only minor epidural PMMA was observed in 20% (8/41) of levels treated, and only contributed to 1 of 10 cases exhibiting diminished cross-sectional area.

### Relatively Low Complication Rates for V and K to Treat OVCFs

Marcia *et al.* in 2018 identified 33 patients undergoing V and K from 7 systematic reviews, 6 cohort studies, 15 randomized clinical trials, and 5 international guidelines; based upon this review, they concluded these procedures were safe, with relatively low complication rates [Table 1].<sup>[7]</sup>

### 30-Day Complication, and Mortality Rates for V/K

Utilizing the 2012-2014 ACS-NSQIP (American College of Surgeons – National Surgical Quality Improvement Program) database of 2433 patients, Choo *et al.* in 2018 looked at the frequency of 30-day complications, readmissions, and mortality rates following V 242(9.9%) vs. K 2191(90.1%) [Table 1].<sup>[2]</sup> Independent risk factors for complications within 30 days included preoperative; dependent status, sepsis, metastatic cancer, wound infections, and in-patient status. The 30-day post-procedural mortality correlated with preoperative; health status, dialysis, metastatic cancer, chronic steroids, and in-patient status. Note both preoperative and postoperative groups included; metastatic cancer and in-patient status. When Kurra *et al.* in 2018 reviewed mortality rates in 6 articles (multicenter prospective, randomized control studies (RCTs)) following K or V for symptomatic OVCFs, they concluded that mortality rates were somewhat lowered by K vs. V, while others determined there were no differences in survival between the 3 treatment modalities (i.e. K, V, NST) [Table 1].<sup>[4]</sup>

### Risk for Recurrent OVCFs

In a retrospective study, Lee *et al.* in 2018 evaluated the risk factors for patients likely to develop recurrent OVCFs after V and K vs. NST [Table 1].<sup>[5]</sup> They evaluated the frequency of recurrent OVCFs for 132 patients originally treated with V, K or NST over a minimum of one year (2007-2016). Notably, 46 of 132 (34.8%) patients demonstrated new OVCF. Major risk factors for OVCFs included; age > 70, low BMD (e.g. Bone Mineral Density of the lumbar spine/femoral neck), utilization of cement augmentation, and failure to take osteoporosis medications.

### CONCLUSIONS

Although the majority of OVCFs are managed with non-surgical treatment (NST), up to 40% with persistent pain and other complaints/symptoms/signs may warrant vertebroplasty (V) or kyphoplasty (K). Both V and K have been shown, in most studies, to result in significantly better pain relief, higher quality of life scores, and increased postoperative vertebral body height when compared with NST. A subset of series demonstrated the superiority of K over V or V over K compared with NST. Nonetheless, most studies documented comparable long-term outcomes utilizing all 3 treatment modalities (V, K, and NST).

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### Conflicts of interest

There are no conflicts of interest.

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