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 verteoplasty (V).
Here we provide a short perspective reviewing the pros and cons for these 3 treatment options for managing traumatic/ataumatic OVCFs.[1-13]

**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].[10] 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].[10] 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].[9] 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].[1]

**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].[12] 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].[7] 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].[10] Beall et al. in 2018 confirmed similar findings [Table 1].[1] 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].[13]

**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].[11] 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].[5] 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].[10] 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].[1] 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].[9, 13]

**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, Rabei 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].[10] 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-hospitals 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       | Hypothesis V/K > Pain Relief and Improved ADL vs CG/NST | 8 V studies | V and K > Pain Relief and Quality life vs. CG/NST | Better pain relief with V > K vs. CG/NST |
|            | 628 CG/NST |               |                             | 2 K studies | Ages 64-80 | Same BMD in all groups | Same Number ALF K/V vs. CG/NST |
| Zhang 2017 | 1328 Pts   | 12 Studies    | 768 PMMA V/K vs 560 CG/NST  | Equal ALF for V/K vs CG/NST | Same BMD in all groups | ODI more reduced for K vs. VAI |
| Beall 2018 | 25 Studies | 5 RCT, 7 PS   | K Trend > Pain Reduction vs V, NST | K > Pain Control Disability vs VAI | 1 Day Postop VAS and ODI Equal V+K | V and K Similar Leakage of Bone Cement and ASF |
| 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 | Same Outcomes K and V on VAS vs ODI |
| 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 | OR Time V-29.6 min K-37.4 min | 1 Day Postop VAS and ODI Equal V+K | 20% (8/41) Epidural Extravasation PMMA; 1/10 < CSA |
| 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 | K, V, NST Same Mortality Rates |
| 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 Mortality | Risk factors- Mortality Health Status, Dialysis, MD 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 Fractures-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: Bone 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/Refraction | 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 128.8% 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]. 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].

**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].

**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 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.

**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]. 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.

**REFERENCES**

1. Beall D, Lorio MP, Yun BM, Runa MJ, Ong KL, Warner CB. Review of Vertebral Augmentation: An Updated Meta-analysis of the Effectiveness. Int J Spine Surg, 2018;12(3):295-321.
2. Choo S, Malik AT, Jain N, Yu E, Kim J, Khan SN. 30-day adverse outcomes, re-admissions and mortality following vertebroplasty/kyphoplasty. Clin Neurol Neurosurg, 2018;174:129-133.
3. Goldstein CL, Chutkan NB, Choma TJ, Orr RD. Management of the Elderly With Vertebral Compression Fractures. Neurosurgery. 2015; 77 Suppl 4:S33-45.
4. Kurra S, Metkar U, Lieberman IH, Lavelle WF. The Effect of Kyphoplasty on Mortality in Symptomatic Vertebral Compression Fractures: A Review. Int J Spine Surg, 2018;12(5):543-548.
5. Lee BG, Choi JH2, Kim DY3, Choi WR4, Lee SG5, Kang CN6. Risk factors for newly developed osteoporotic vertebral compression fractures following treatment for osteoporotic vertebral compression fractures. Spine J, 2018 Jun 26. pii: S1529-9430(18)30626-0.
6. Lis E, Laufer I, Barzilai O, Yamada Y, Karimi S, McLaughlin L, et al. Change in the cross-sectional area of the thecal sac following balloon kyphoplasty for pathological vertebral compression fractures prior to spine stereotactic radiosurgery. J Neurosurg Spine. 2018 Oct 1:1-8.
7. Marcia S, Muto M, Hirsch JA, Chandra RV, Carter N, Crivelli P, et al. What is the role of vertebral augmentation for osteoporotic fractures? A review of the recent literature. Neuroradiology. 2018 Aug;60(8):777-783.
8. Rabei R, Patel K, Ginsburg M, Patel MV, Turkba UC, Arslan B, et al. Percutaneous Vertebral Augmentation for Vertebral Compression Fractures: National Trends in the Medicare Population (2005-2015). Spine (Phila Pa 1976), 2019;44(2):123-133.
9. Wang B, Zhao CP, Song LX, Zhu L. Balloon kyphoplasty versus percutaneous vertebroplasty for osteoporotic vertebral compression fracture: a meta-analysis and systematic review. J Orthop Surg Res, 2018;13(1):264.
10. Wang F, Wang LF, Miao DC, Dong Z, Shen Y. Which one is more effective for the treatment of very severe osteoporotic vertebral compression fractures: PVP or PKP? J Pain Res., 2018;11:2625-2631.
11. Yuan WH, Hsu HC, Lai KL. Vertebroplasty and balloon kyphoplasty versus conservative treatment for osteoporotic vertebral compression fractures: A meta-analysis. Medicine (Baltimore), 2016;95(31):e4491.
12. Zhang H, Xu C, Zhang T, Gao Z, Zhang T. Does Percutaneous Vertebroplasty or Balloon Kyphoplasty for Osteoporotic Vertebral Compression Fractures Increase the Incidence of New Vertebral Fractures? A Meta-Analysis. Pain Physician, 2017;20(1):E13-E28.
13. Zhu RS, Kan SL, Ning GZ, Chen LX, Cao ZG, Jiang ZH, et al. Which is the best treatment of osteoporotic vertebral compression fractures: balloon kyphoplasty, percutaneous vertebroplasty, or nonsurgical treatment? A Bayesian network meta-analysis. Osteoporos Int, 2019, Jan 12. doi: 10.1007/s00198-018-4804-2. [Epub ahead of print]

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