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# Comparative study between vertebroplasty and kyphoplasty in management of osteoporotic vertebral body fractures

Mahmoud M. Gamal<sup>1\*</sup>, Mohammad Taghyan<sup>1</sup> and Ahmed Abdalla Ismail<sup>1</sup>

## Abstract

**Background** Percutaneous vertebroplasty and percutaneous kyphoplasty are effective minimally invasive procedures in reducing pain and improving the quality of life in patients with osteoporotic vertebral compression fractures with different degrees, but it may lead to serious neurological complications.

**Results** Twenty-five patients were included in our study. Both techniques were done under local anesthesia using bi-pedicular approach. All cases were assessed using plain radiographs pre- and post-operative, Visual Analogue Scale for pain, and modified Oswestry Disability Index for functional disability. Thirteen patients had vertebroplasty and 12 patients had kyphoplasty. The mean age for vertebroplasty group was  $66.94 \pm 6.71$ , while in kyphoplasty group, the mean age was  $70.38 \pm 9.21$ . In vertebroplasty group, there were ten females and three males, while in kyphoplasty group, there were nine females and three males. All cases had single vertebral level affection except one patient in the vertebroplasty group that had double-level affection. In vertebroplasty group, ten patients had lumbar spine affection, two patients had dorsal spine affection and one patient had combined dorsal and lumbar spine affection. In kyphoplasty group, ten patients had lumbar spine affection and two patients had dorsal spine affection. The mean post-operative Visual Analogue Scale was 0.46 and 0.50 in vertebroplasty and kyphoplasty groups, respectively. The mean post-operative modified Oswestry Disability Index became 4.15 and 4 in vertebroplasty and kyphoplasty groups, respectively. The mean post-operative local kyphotic angle was  $6.0^\circ$  and  $6.50^\circ$  in vertebroplasty and kyphoplasty groups, respectively. The mean vertebral height became 73.15% and 75% post-operatively in vertebroplasty and kyphoplasty groups, respectively. The intra-operative cement leakage occurred in three cases of vertebroplasty group and one case of kyphoplasty group ( $P=0.644$ ). The cost of kyphoplasty was very high in comparison with vertebroplasty.

**Conclusions** There is no difference between vertebroplasty and kyphoplasty as regard pain relief, improved quality of life, correction of kyphotic angle, vertebral height restoration and the incidence of cement leakage except that kyphoplasty has a very high cost than vertebroplasty. Therefore, both techniques have an equal effect in treating osteoporotic vertebral compression fractures.

## Background

Patients with osteoporotic vertebral compression fractures often complain of back pain in 85%. The degree of fracture can correlate with the patients' quality of life (motor, mental and respiratory function), the mortality rate, and the risk of new fractures [1].

Percutaneous cementoplasty, including vertebroplasty and kyphoplasty, is a relatively safe, simple, and

\*Correspondence:

Mahmoud M. Gamal

Mahmoud\_gamal20102000@yahoo.com

<sup>1</sup> Department of Neurosurgery, Faculty of Medicine, Asyut University, Asyut, Egypt

commonly performed interventional procedure for the management of osteoporotic vertebral compression fractures. However, serious complications were reported throughout the procedure including pulmonary embolism, infection, paraplegia, and an occurrence of a new fracture in an adjacent vertebra after vertebroplasty or kyphoplasty [2].

Until the introduction of percutaneous vertebroplasty, the treatment options for osteoporotic vertebral compression fractures were bed rest and pain management. The immediate and delayed pain relief attained with percutaneous vertebroplasty is making the procedure an accepted one and is challenging the medical treatment of bed rest and analgesics [3].

In the last few years, substantial progress has been made for providing an adequate percutaneous augmentation of a vertebra following osteoporotic vertebral compression fractures as regard vertebral height, kyphotic angle, and cement leakage. Percutaneous kyphoplasty which involves the creation of a cavity in the vertebral body with a balloon [Inflatable bone tamp] before injecting polymethylmethacrylate bone cement was first designed by Wong and Reiley and was approved by the Food and Drug Administration for clinical use in 1998 [4].

However, the very high cost of kyphoplasty makes an obstacle for its use in our province. Hence, we did our study to compare between both techniques in treating osteoporotic vertebral compression fractures as regard clinical improvement, vertebral height restoration, kyphotic angle correction, cement leakage, and cost.

## Methods

This study was conducted in Neurosurgery department, Asyut university hospitals, Asyut, Egypt between December 2018 and February 2021. Percutaneous vertebroplasty and kyphoplasty were performed for 25 patients (13 vertebroplasty cases and 12 kyphoplasty cases) complaining of back pain due to osteoporotic vertebral compression fractures and not responding to conservative measures and not associated with neurological affection.

All patients were evaluated pre-operatively through history and clinical examination (local tenderness and neurological examination), imaging studies (X-rays, CT, MRI, and DEXA scan), and routine laboratory and medical evaluation to assess co-morbidities.

Both techniques (Vertebroplasty and kyphoplasty) were performed under local anesthesia using X-ray fluoroscopy (Technix TCA 5 C-arm made in Italy and GE HealthCare C-arm, OEC Elite made in the United States) in the operative room. The patient was pre-medicated with intra-venous paracetamol 1 g (Perfalgan bottle) and antibiotic (Claforan 1 g) and placed in prone

position on a standardized cushion. The fractured level is identified using the lateral X-ray fluoroscopy. A para-median spinal needle was used for injection of local anesthesia and localization of entry point. Under fluoroscopy guidance, the beveled vertebroplasty and kyphoplasty needles are gently introduced into the vertebral body through a trans-pedicular route through a 0.5 cm stab incision (Fig. 1). When lateral fluoroscopy shows that the tip of the needle has passed beyond 50% of the length of the pedicle, and postero-anterior projection shows a position of the needle lateral to the medial pedicle wall, a safe entrance into the vertebral body has been achieved.

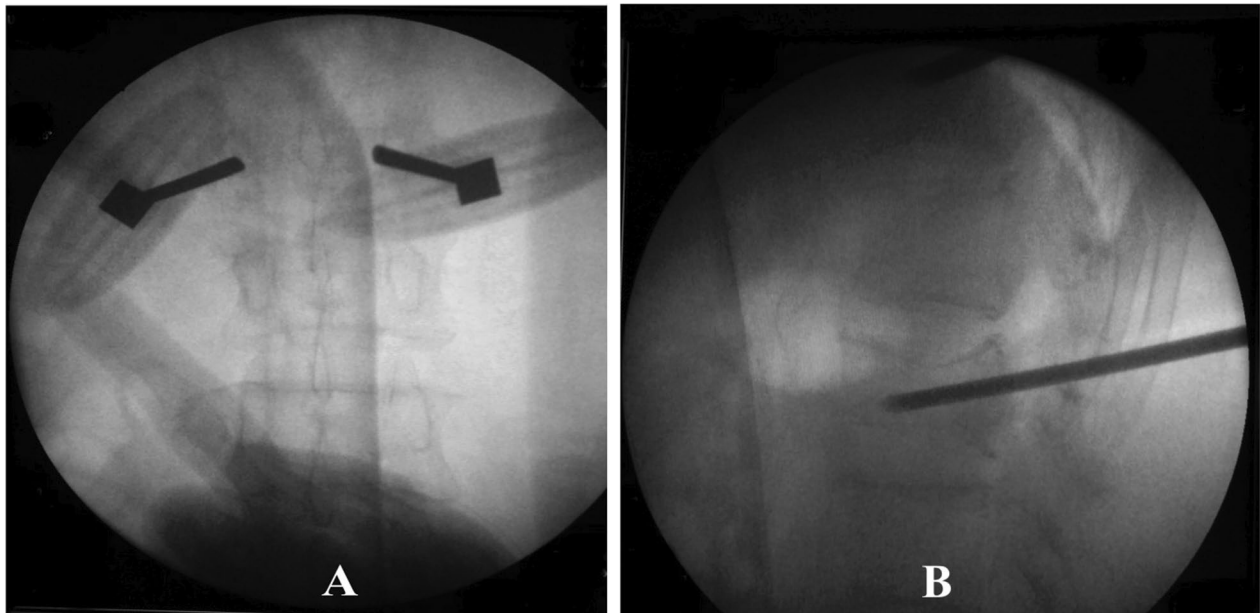
At this point, if we inject polymethylmethacrylate bone cement in the needle after removal of the stylet, vertebroplasty will be completed, while in kyphoplasty, the stylet of the needle is removed and the cavity inside the vertebral body is prepared using the drill for the kyphoplasty balloon catheter insertion. We start to inflate the balloon under continuous fluoroscopic monitoring until realignment of the vertebral plates, maximum pressure of the balloon catheter, and maximum volume of the balloon catheter and/or contact with any of the cortical walls. After that we deflate and remove the balloon and start to inject polymethylmethacrylate bone cement (Fig. 2).

We used the Italian-type polymethylmethacrylate bone cement (Osteofix, Tsunami medical, ®Italy, high viscosity long working cement, and 28% barium sulphate). It is of an appropriate viscosity, self-curing polymethylmethacrylate bone cement. This allows easy injection through the cannulas and controls the volume of the injected cement. Barium sulphate of about 28% allows accurate evaluation of cement distribution under fluoroscopy.

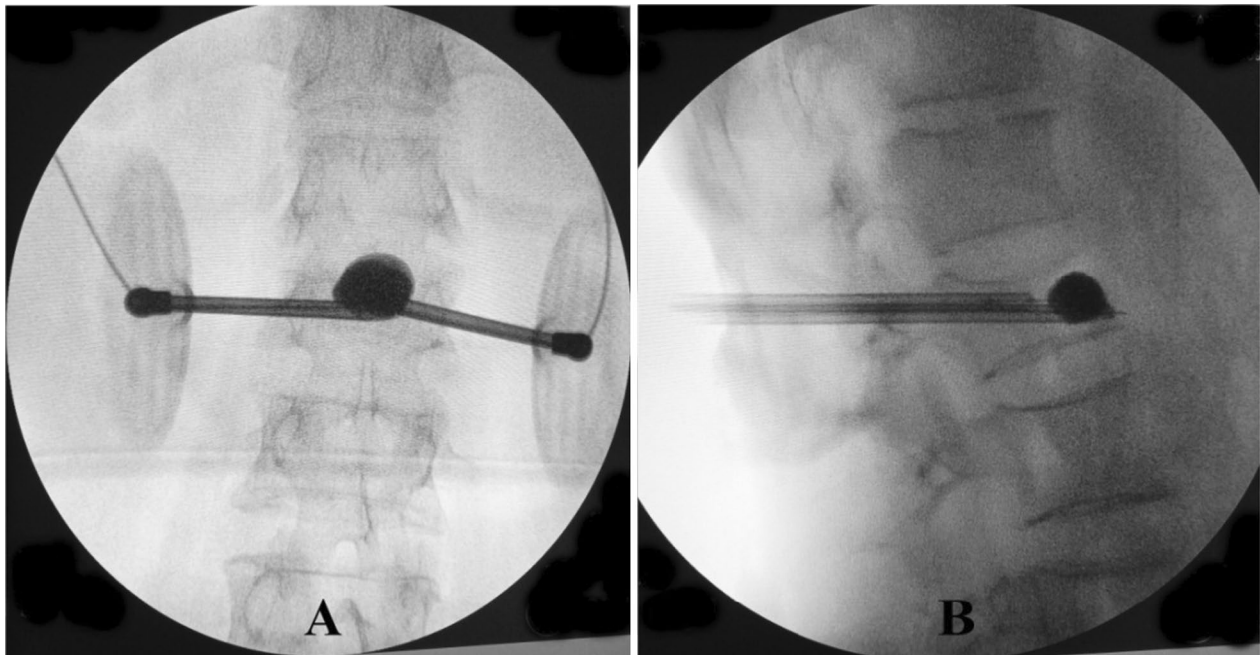
Post-operatively, patients were given appropriate analgesia (Paracetamol 1 g) and antibiotic prophylaxis (Claforan 1 g). Antibiotics are given for further 1 week. Patients were instructed to remain recumbent in bed for 2 h. After this time, they were allowed to sit or walk and then discharged.

Post-operative evaluation was carried out at regular intervals; immediate post-operative, 1 month, 3 month and 6 month post-operative (Figs. 3, 4).

Each time, patients were evaluated clinically through neurological examination, Visual Analogue Scale for pain, modified Oswestry Disability Index for functional disability, and radiological through plain X-rays to assess the injected level, adjacent and non-adjacent level involvement and follow up the kyphotic angle and vertebral height. In addition, we evaluated complications, such as cement leakage, infection, and continuous pain.



**Fig. 1** Osteoporotic vertebral compression fractures of the third lumbar vertebra after insertion of vertebroplasty needles antero-posterior (A) and lateral views (B)



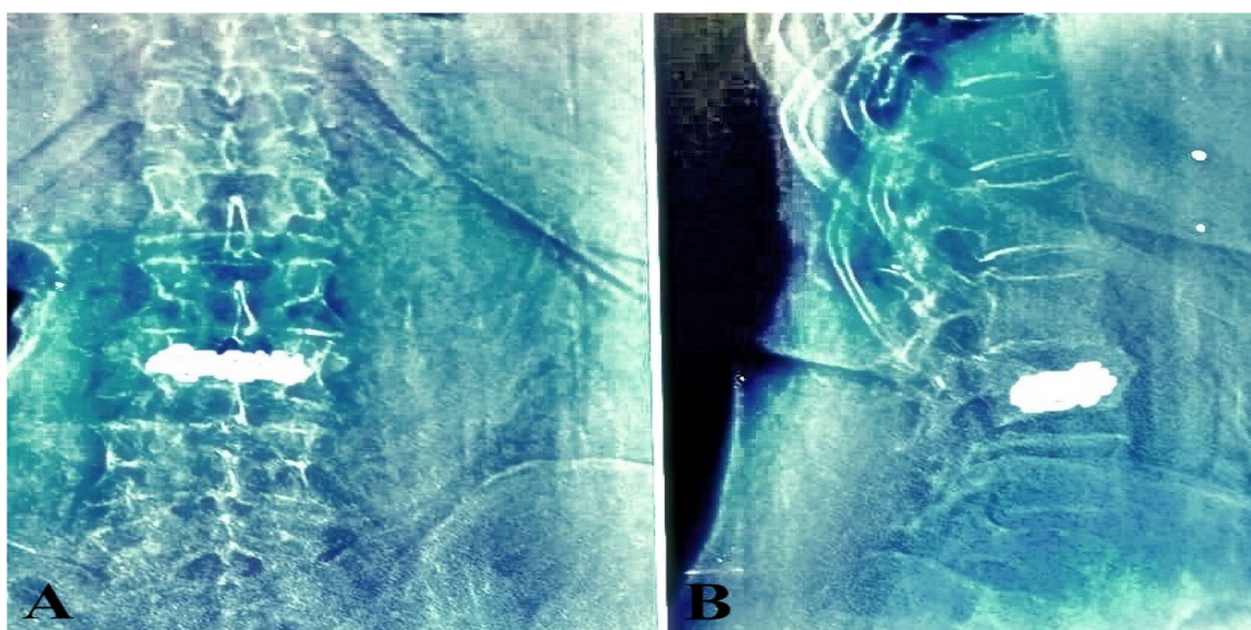
**Fig. 2** Osteoporotic vertebral compression fractures of first lumbar vertebra after inflation of kyphoplasty balloon antero-posterior (A) and lateral views (B)

## Results

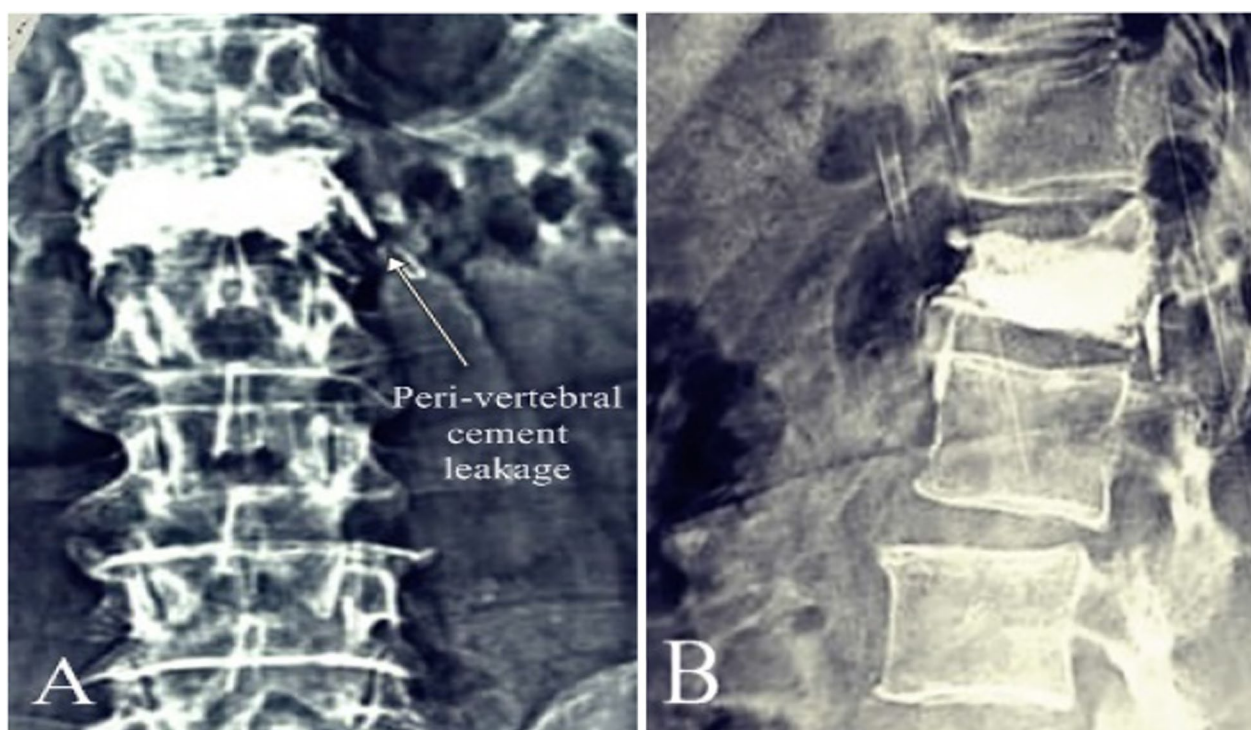
Percutaneous vertebroplasty and kyphoplasty were performed on 25 patients (13 vertebroplasty cases and 12 kyphoplasty cases) who suffered from painful

osteoporotic vertebral compression fractures. There were three males in each group and ten females in vertebroplasty group and nine in the kyphoplasty group. The age in the two groups ranged between 60 and 85 years, with





**Fig. 3** Osteoporotic vertebral compression fractures of third lumbar vertebra after vertebroplasty 6 month post-operative antero-posterior (A) and lateral views (B)



**Fig. 4** Osteoporotic vertebral compression fractures of first lumbar vertebra after kyphoplasty 6 month post-operative antero-posterior (A) and lateral views (B) with peri-vertebral cement leakage

the mean age was  $66.94 \pm 6.71$  in vertebroplasty group and  $70.38 \pm 9.21$  in the kyphoplasty group (Table 1).

Of the 25 cases, 24 cases had only single level affection and one case had double level affection in the thoracic and lumbar regions (one vertebroplasty case). In vertebroplasty, ten patients (76.9%) had lumbar spine affection, two patients (15.4%) had dorsal spine affection, and one patient had combined dorsal and lumbar spine affection (7.7%), while in kyphoplasty, ten patients (83.3%) had lumbar spine affection and two patients (16.7%) had dorsal spine affection (Table 1).

All patients in both groups had significant pain relief and regained ambulation without pain immediately post-operative which last throughout the follow-up period. The mean pre-operative Visual Analogue Scale was  $6.77 \pm 1.62$  in vertebroplasty group (range 5–10) and  $7.67 \pm 1.70$  in kyphoplasty group (range 5–10) which changed post-operatively to  $0.46 \pm 0.93$  in vertebroplasty group (range 0–3), and  $0.50 \pm 0.96$  in kyphoplasty group (range 0–4) ( $P > 0.05$ ). The mean pre-operative modified Oswestry Disability Index was  $55.54 \pm 8.67$  (range 40–70) and  $57.67 \pm 9.89$  (range 40–70) that became post-operatively  $4.15 \pm 3.37$  (range 2–12) and  $4.0 \pm 2.58$  (range 2–10) for vertebroplasty and kyphoplasty groups, respectively ( $P > 0.05$ ) (Table 2).

According to vertebral body height, the mean pre-operative vertebral height was  $63.62 \pm 3.71\%$  in vertebroplasty group (range 56–68%) and  $66.63 \pm 6.91\%$  in the kyphoplasty group (range 54.3–76%) which changed post-operatively to  $73.15 \pm 1.41\%$  (range 71–75%) and  $75.0 \pm 3.37\%$  (range 77–82%) in vertebroplasty and kyphoplasty groups, respectively ( $P > 0.05$ ). The mean pre-operative kyphotic angle was  $9.18^\circ \pm 1.33^\circ$  (range  $7.9^\circ$ – $12.5^\circ$ ) and

$10.04^\circ \pm 1.36^\circ$  (range  $8^\circ$ – $12.5^\circ$ ) that changed post-operatively to be  $6.0^\circ \pm 0.87^\circ$  (range  $5.3^\circ$ – $6.8^\circ$ ) and  $6.50^\circ \pm 0.45^\circ$  (range  $5.6^\circ$ – $8.5^\circ$ ) in vertebroplasty and kyphoplasty groups, respectively ( $P > 0.05$ ) (Table 2).

Regarding complications, the total incidence of cement leakage was 16% (four cases). The intra-discal cement leakage occurred in two cases of vertebroplasty (8%), while the peri-vertebral cement leakage occurred in two cases (8%), one of them occurred with vertebroplasty, while the other occurred with kyphoplasty.

The amount of cement injected in both techniques ranged between 3 and 6 ml. However, the amount used in complicated cases was 3–4 ml which is equal or even less than the amount of cement injected in non-complicated cases. None of our patients developed adjacent vertebral level fractures, postoperative neurological deficit, and/or infection in the post-operative or throughout the follow-up period (Table 3).

## Discussion

Percutaneous vertebroplasty and kyphoplasty became popular procedures in treatment of painful non-complicated osteoporotic vertebral compression fractures. However, there is a wide controversy about their efficacy in pain relief, improving quality of life, vertebral height restoration, kyphotic angle correction, the amount of cement used and its complications. In our study, we evaluate and compare the results of both procedures in the treatment of painful non-complicated osteoporotic vertebral compression fractures.

Regarding age and sex, our results showed that osteoporotic vertebral compression fractures mostly occur with increasing age with most of the cases occur above

**Table 1** Patient demographics and vertebral affection

	Number of patients	Sex		Age Mean $\pm$ SD	Level of vertebral affection		
		♀	♂		Dorsal	Lumbar	Dorsal + lumbar
Vertebroplasty group	13	10	3	$66.94 \pm 6.71$	2	10	1
Kyphoplasty group	12	9	3	$70.38 \pm 9.21$	8	10	0

SD standard deviation

**Table 2** Post-operative outcomes

	Visual Analogue Scale	Modified Oswestry Disability Index	Vertebral height	Kyphotic angle
Post-operative Mean $\pm$ SD				
Vertebroplasty group	$0.46 \pm 0.93$	$4.15 \pm 3.37$	$73.15 \pm 1.41\%$	$6.0^\circ \pm 0.87^\circ$
Kyphoplasty group	$0.50 \pm 0.96$	$4.0 \pm 2.58$	$75.0 \pm 3.37\%$	$6.50^\circ \pm 0.45^\circ$
P value	0.917	0.902	0.082	0.088

SD standard deviation

**Table 3** Comparison between peri-operative complications after percutaneous vertebroplasty and kyphoplasty

	Vertebroplasty group	Kyphoplasty group	P value
Intra-operative cement leakage	3 (23.1%)	1 (8.3%)	0.644
Post-operative adjacent and non-adjacent vertebral level fractures	0	0	–
Post-operative neurological deterioration	0	0	–
Complications related to intra-operative anesthesia and positioning	0	0	–
Post-operative infection	0	0	–

the age of 60 and the females being mostly affected than males and this may be related the normal wear and tear phenomenon and the burden of pregnancy and lactation among females. Our results coincide with Deng et al. [5] who studied 85 patients with osteoporotic vertebral compression fractures treated with either vertebroplasty or kyphoplasty and found that females were more affected than males (14 males and 27 females in vertebroplasty group and 16 males and 28 females in kyphoplasty group) and the average age of these patients was  $72.18 \pm 3.78$  years (the average age was  $71.80 \pm 4.05$  years and  $72.52 \pm 3.52$  years in vertebroplasty and kyphoplasty groups, respectively). We also agreed with Dong et al. [6] who studied 86 patients (52 women and 34 men, aged 60–81 years, with a mean age of 70.1 years).

According to Visual Analogue Scale, our results showed that vertebroplasty and kyphoplasty were effective in reducing pain of our patients within a short period of time and this improvement was statistically highly significant ( $P < 0.001$ ). However, with comparing the mean Visual Analogue Scale and standard deviation (SD) results of both techniques post-operatively, it was found to be statistically insignificant 0.917 ( $P > 0.001$ ). Our results agreed with Wang et al. [7] who found, in their meta-analysis and systematic review, that there was no statistical difference in Visual Analogue Scale between the vertebroplasty and kyphoplasty groups. We also agreed with Dong et al. [6] who found, in their 86 patients, that vertebroplasty and kyphoplasty are effective procedures for the reduction of pain in osteoporotic vertebral compression fractures, and they have the same effect on pain reduction. In addition, we coincide with Santiago et al. [8] in their study (30 vertebroplasty cases compared with 30 kyphoplasty cases), who found that there was no clinical difference between both techniques as regard pain relief.

Regarding modified Oswestry Disability Index, the benefit to patients extends beyond simple pain relief into the improvement of quality of life. The improved outcome of post-operative modified Oswestry Disability Index values compared with pre-operative values was found to be statistically highly significant ( $P < 0.001$ ); however, with comparing the post-operative mean and standard

deviation (SD) results of both techniques, it was found to be insignificant ( $P > 0.001$ ). Our results agreed with Bernardo et al. [9] who found, in their study of 199 kyphoplasty cases compared with 205 vertebroplasty cases, that there were no significant differences between the two treatment modalities regarding the outcomes of quality of life and dysfunction score. In addition, we agreed with Santiago et al. [8] and Ateş et al. [10] who found that there was no functional difference between both techniques and both of them are effective treatment methods for functional recovery and pain relief in osteoporotic fractures of the vertebra.

Regarding vertebral height, percutaneous vertebroplasty does not aim at vertebral height restoration as compared to percutaneous kyphoplasty. Despite this fact, all of our cases had varying degrees of increase in the vertebral height following vertebroplasty as well as kyphoplasty. The improved outcome of post-operative vertebral height values compared with pre-operative values was found to be statistically highly significant ( $P < 0.001$ ), and with comparing the post-operative mean and standard deviation (SD) results of both techniques, it was found to be statistically insignificant ( $P > 0.001$ ) and this may be due to small sample of the research. Our results agreed with Griffoni et al. [11] who found that there were no differences between vertebroplasty (70 cases) and kyphoplasty (69 cases) regarding vertebral height restoration. Both showed a significant vertebral height restoration. In addition, we agreed with Wei et al. [12] who reported, in their systematic review and meta-analysis, the absence of significant differences in vertebral height restoration between the vertebroplasty and kyphoplasty groups. We also coincide with Hiwatashi et al. [13] who reported that both kyphoplasty (40 cases) and vertebroplasty (66 cases) achieved the same degree of vertebral height restoration.

Regarding kyphotic angle, the angle was initially decreased due to partial correction of kyphosis by the cement pressure and also by the hyper-extended prone position. The improved outcome of post-operative kyphotic angle values compared with pre-operative values was found to be statistically highly significant ( $P < 0.001$ ), and with comparing the post-operative mean and standard deviation (SD) results



of both techniques, it was found to be insignificant ( $P > 0.001$ ). Our results coincide with Chang et al. [14] who found, in their study of 56 cases, that kyphosis correction in the vertebroplasty and kyphoplasty groups was not statistically significant between the two groups at any timepoint (all  $P > 0.05$ ). In addition, we agreed with Garnier et al. [15] who found that vertebroplasty and kyphoplasty (in a retrospective review of a multi-centre cohort of 127 consecutive patients) produced similar outcomes in reduction of the kyphotic deformity. They reported that the kyphotic angle improvements noted in their study in both techniques were not statistically significant. We also agreed with Hiwatashi et al. [13] who reported that both kyphoplasty (40 cases) and vertebroplasty (66 cases) achieved the same degree of improvement of the kyphotic angle.

Regarding cement volume and leakage, there is no relation in our study between neither the technique nor the volume of cement used and the leakage. We agreed with Hu et al. [16] who found that intra-operative cement leakage occurred in 5/91 cases of kyphoplasty group and 12/70 cases in vertebroplasty group, indicating that kyphoplasty is relatively better. We also coincide with Marcia et al. [17] who found, in their review of the recent literature, that the overall complication rates are low and similar for both vertebroplasty and kyphoplasty.

In addition, we matched with Zou et al. [18] who found, in their study of 2344 patients who underwent vertebroplasty or kyphoplasty due to osteoporotic vertebral compression fractures, that although theoretically speaking, the more bone cement is injected, the higher the probability of pulmonary cement embolism will appear, but according to our statistics, the total bone cement filling amount of pulmonary cement embolism group is not significantly increased than that of non-pulmonary cement embolism group ( $P = 0.068$ ) in both techniques. In addition, we agreed with Self et al. [19] who found that for patients undergoing kyphoplasty (136 cases), outcomes were not associated with the total injected cement volume. We also coincide with Martinčič et al. [20] in their study of 30 patients, and found that the minimum volume of cement is recommended for vertebroplasty. In the average thoraco-lumbar vertebrae, this means 4–6 ml of cement.

In our study, the cost of kyphoplasty was very high, while for vertebroplasty, it was low. We agreed with Cheng et al. [21] who found, in their retrospective cohort study, that there is a huge difference between the cost of kyphoplasty and vertebroplasty ( $P < 0.01$ ). We also coincide with Wang et al. [22] who found that kyphoplasty has a higher material cost than vertebroplasty in their meta-analysis of the literature.

## Conclusion

Both percutaneous vertebroplasty and kyphoplasty are simple day care procedures that can be performed under local anesthesia with minimal intra-venous sedation, C-arm image intensifier, and bone cement.

Both are equally effective minimally invasive procedures for treatment of osteoporotic vertebral compression fractures except for the cost. Both provide pain relief and mechanical stabilization within a vertebral body to prevent further vertebral body collapse and achieve better functional results. In addition, both vertebroplasty and kyphoplasty help restoration of daily activities and improvement of the psychological status of the patients.

Complications associated with bone cement injection are infrequent and mostly minor that is cement leakage.

## Abbreviations

CT	Computed tomography
MRI	Magnetic resonance imaging
DEXA	Dual X-ray absorptiometry
g	Gram
cm	Centimeter
SD	Standard deviation
ml	Milli-liter

## Acknowledgements

Not applicable.

## Author contributions

MG did the design of the work; the acquisition, analysis, and interpretation of data. MT author had approved the submitted version. AA had drafted the work or substantively revised it. All authors read and approved the final manuscript.

## Funding

No funding was required.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

Our research had been approved by a medical ethics committee, Asyut University with a reference number 17200254 dated on 4/10/2018 with the consent to participate was obtained by the patient.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

Received: 28 December 2022 Accepted: 26 April 2023  
Published online: 15 May 2023

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