European Review for Medical and Pharmacological Sciences 2023; 27: 8540-8549

The relationship between pain relief and the amount and distribution of injected cement in kyphoplasty for osteoporotic vertebral fractures

S. KHALILOLLAH[1], H. ABDOLHOSEINPOUR[1], E. REZAEI[1], M.S. FAKHR[2]

[1]Department of Neurosurgery, Bouali Teaching Hospital, Faculty of Medicine, Tehran Medical Sciences Branch, Islamic Azad University, Tehran, Iran
[2]Faculty of Medicine, Tehran Medical Sciences Branch, Islamic Azad University, Tehran, Iran

Abstract. – OBJECTIVE: This study aimed to compare the relationship of pain relief with the amount and distribution of injected cement in kyphoplasty for osteoporotic vertebral fractures.

PATIENTS AND METHODS: This cohort study was conducted on 90 patients with osteoporotic vertebral fractures who needed chronic pain medication. Patients underwent kyphoplasty balloon surgery, and polymethylmethacrylate (PMMA) or bone cement was injected into the created cavities and the volume of injected cement was recorded. After the surgery, the distribution of cement was measured using a computed tomography (CT) scan in the coronal, sagittal, and axial axes of the vertebra, and the percentage of cement distribution was evaluated using Photoshop software in these three axes, followed by the pattern of cement distribution. The cement was measured in the entire vertebra. The patients were evaluated over a period of 6 months, and the amount of pain improvement was measured by the VAS scale in 24 hours, two weeks, six weeks, and six months after surgery. In this study, the data of 90 patients with a mean age of 72.5±10.9 years were included in the study. The mean volume of cement injected was 1.2±5.8 cc, followed by the mean percentage of cement distribution (47.7±7.4%); the mean pain score before the operation (8.7±1.3), the mean pain score 24 hours after the operation (7.7±1.4), the mean pain score 2 weeks after the operation (4.8±1.3), the mean pain score 6 weeks after the operation (3.6±1.2) and the mean pain score 6 months after the operation (3.5±1.4) were evaluated after collection.

RESULTS: The pain intensity 24 hours after the operation had a significant positive correlation with the percentage of cement distribution and pain intensity before the operation. The intensity of pain 2 weeks after the operation was positively correlated with the age of the patients and the intensity of pain before the operation. The pain intensity 6 weeks after the operation was significantly correlated with the age of the patients and the pain intensity before the operation. The intensity of pain 6 months after the operation was positively linked to the age of the patients and negatively correlated with the percentage of cement distribution. The pain reduction has changed significantly in the 4 measured intervals, and during a period of 6 months, there was a significant improvement in the pain level of the patients continuously. It was found that the rate of recovery of the patient's pain has increased by increased distribution of injected cement. Although this reduction in pain during the 6-month period was not significantly related to the variables of gender, smoking, history of corticosteroid use, and the volume of injected cement.

CONCLUSIONS: The balloon kyphoplasty is a safe and successful method for treating symptomatic vertebral fractures. Kyphoplasty is associated with significant pain relief, improved quality of life, and kyphosis correction. The volume of cement injected had no effect on reducing patients' pain after the operation, but a higher percentage of cement distribution was associated with a better response in patients.

Key Words:
Kyphoplasty, Pain, Osteoporosis, Vertebral column, Cement injection.

Introduction

Osteoporosis is a metabolic bone disease that is characterized by a decrease in bone density and bone strength, thus increasing the risk of fracture[1]. Osteoporosis risk factors are divided into two categories: non-modifiable and modifiable. Age, gender, race, and genetic characteristics are included in the unmodifiable category. Weight, smoking, low physical activity, long-term use of glucocorticoids, and insufficient intake of calcium are included in the modifiable category. Major risk factors consisted of old

Corresponding Author: Hesam Abdolhoseinpour, MD; e-mail: abdolhosseinpoor@yahoo.com

age, osteoporotic fracture after 73 years of age, history of osteoporotic fracture in first-degree relatives, history of systemic glucocorticoid use for more than three months, primary hyperparathyroidism, high probability of falling, hypogonadism, and menopause. Minor factors include rheumatoid arthritis, insufficient intake of calcium and vitamin D, smoking, weight less than 54 kg, and weight loss[2-5].

As mentioned, society's aging inevitably causes an increase in the incidence of osteoporosis and related fractures, which is associated with an increase in the social and healthcare economic burden[6]. Vertebral fractures are generally considered among the most common types of osteoporotic fractures, affecting 1.4 million patients worldwide annually[7]. Vertebral compression fractures caused by osteoporosis cause chronic back pain, and kyphosis of the spine and decrease the quality of life and survival[8]. Spine surgeries, such as vertebroplasty and kyphoplasty, can also be used if pain persists after conservative treatment[9].

The vertebroplasty procedure involves injecting bone cement, such as polymethylmethacrylate (PMMA), into the fractured body of the vertebra. This will prevent the body of the vertebra from falling further. However, some patients undergoing vertebroplasty experience vertebra compression or new fractures in the vertebra at the site. Also, the occurrence of subsequent fractures after vertebroplasty is not uncommon[10]. Although conservative treatments such as oral analgesics and bed rest can relieve acute pain, surgical treatment is still the optimal choice for most patients with osteoporotic vertebral fractures[11]. The risk of recurrent fractures after 1 previous fracture can increase 4 times, and approximately one-third of patients experience another fracture within 5 years[12].

Kyphoplasty has been recommended as a more advanced and improved method for the treatment of osteoporotic vertebral fractures in recent decades. Compared to vertebroplasty, it has been proven that kyphoplasty improves the height of the affected vertebrae and the local kyphotic angles without increasing the rate of bone cement extravasation (BE) and degeneration of the adjacent segment[13-16]. Reports of previous studies[17-20] have shown kyphoplasty as a minimally invasive method in improving pain in patients with vertebral fractures. Therefore, the aim of this study is to compare the relationship between pain relief and the amount and distribution of injected cement in kyphoplasty for osteoporotic vertebral fractures.

Patients and Methods

Study Design

This cohort study included patients who were candidates for kyphoplasty due to osteoporotic vertebral fractures in Bo Ali and Mehrad hospitals in Tehran, Iran, from 2021 to 2022. Patients who met the inclusion and exclusion criteria were included in the study using a convenience sampling method. Inclusion criteria included: definite diagnosis of osteoporotic vertebral compression fracture (OVCF) by x-ray, computed tomography (CT) scan or magnetic resonance imaging (MRI), definite diagnosis of osteoporosis by bone densitometry (T score <-2.5), no history of percutaneous vertebral plasty (PKP) surgery, need for painkillers and sedatives, at least 6 months of follow-up and having informed consent.

Exclusion criteria were spinal cord or nerve root injury with or without neurological disorder, metastatic spinal tumor, bleeding diseases such as hemophilia, having infectious diseases, patient death within 6 months of follow-up, and simultaneous presence of multiple vertebral fractures.

Sample Size

The sample volume was determined using G-power software (latest ver. 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). Considering the power of 80%, and confidence of 95%, the sample size was calculated by assuming the minimum clinically significant change of 2 degrees and the ratio of 9 to 1 improvement. Based on the minimum pain level (visual analog scale: 1.4±1.1), 7 cases were suggested to be included in the no-recovery group, whereas 63 cases were suggested to be assigned to the pain recovery group, corresponding to a total of 70 individuals. To enhance reliability, based on a maximum pain of 1.6±1.5, we included 9 cases in the no-recovery group and 81 cases in the pain recovery group, corresponding to a total of 90 cases in this study[15].

Procedure

At first, by performing detailed clinical examinations, the vertebra fracture that caused the chronic back pain was identified. The vertebra in question was examined by a CT scan before and after the surgery. Also, all patients were examined in terms of bone densitometry and were included in the study if the T score was less than -2.5. All patients were hospitalized one day before kyphoplasty surgery for pretreatment.

For patients who underwent kyphoplasty surgery, two cannulas were transpedicular inserted into the crushed body of the vertebrae and cavities with a volume of 4 to 5 ml were created with balloons inserted through the cannulas. After removing the balloons, PMMA was injected into the created cavities and hardened within a few minutes. The amount of cement used in each operation and the amount of operation time were recorded by the relevant surgeon.

Also, the distribution of cement after surgery was measured using a CT scan in the coronal, sagittal, and axial axes of the vertebra, and the percentage of cement distribution was evaluated using Photoshop software in these three axes. After that, the distribution of cement in the entire vertebra was measured. The method of calculating the amount of flattening is as follows: the cross-section with the highest amount of distribution in each of the axial, coronal, and sagittal axes was selected, and the pixel ratio of the part occupied by bone cement to the entire vertebral body was calculated using Photoshop software. According to the distribution pattern, the percentage of distribution in the entire vertebra was calculated and entered into the data table. For example, the following CT scan is related to one of the patients (Figure 1).

After 2 hours of surgery, the patients were allowed to move freely with the help of a back protector. The obtained information was recorded in pre-prepared tables, the patients were evaluated in a 6-month interval, and the pain improvement was measured using the VAS scale at 24 hours after surgery, two weeks, and six weeks after surgery, and six months after surgery, and then recorded in a questionnaire. Afterward, the relationship of pain relief with the amount of injected cement and the amount of cement distribution was compared. All kyphoplasty patients were discharged 48 hours after surgery.

Statistical Analysis

Quantitative data were presented as mean, and standard deviation, and qualitative data were expressed as frequency and percentage. The

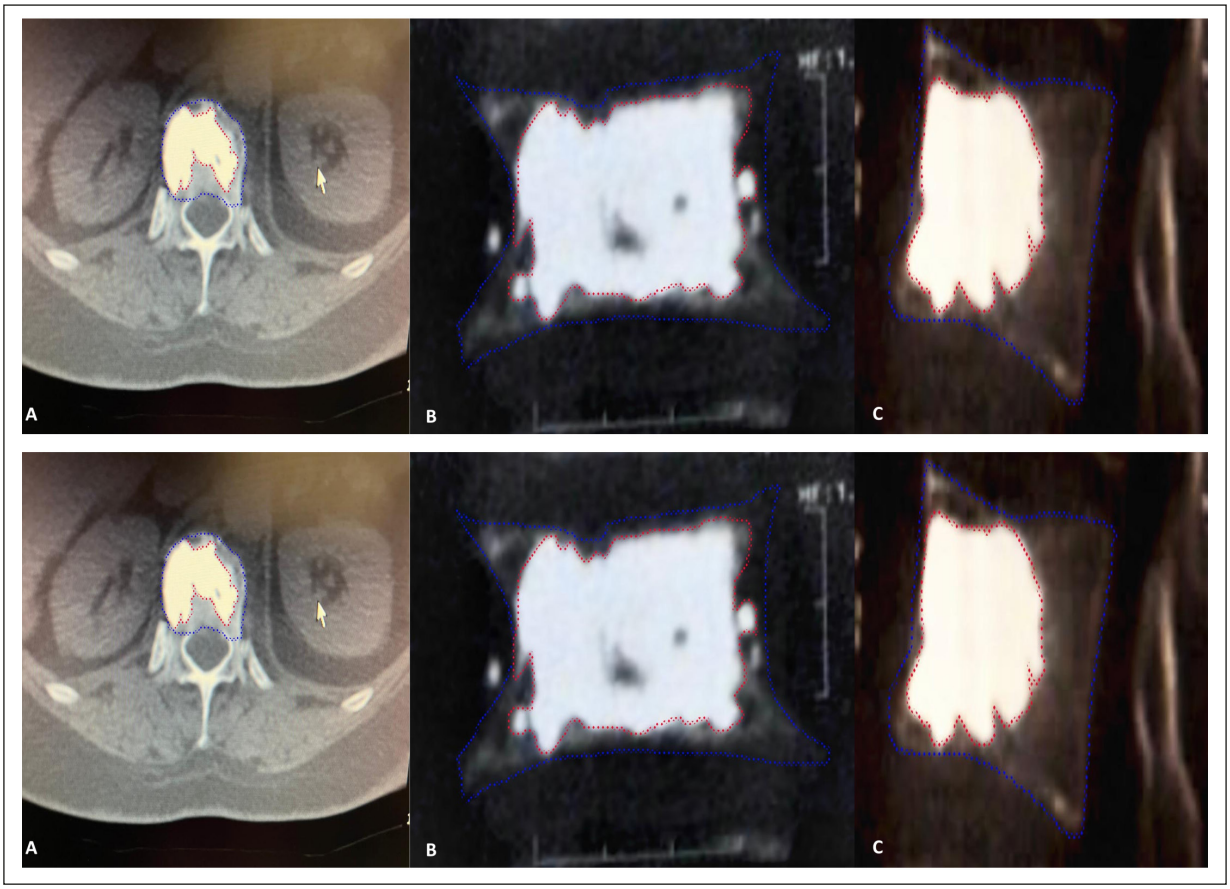

Figure 1. CT images of a patient. **A**, Axial cut. **B**, Coronal cut. **C**, Sagittal cut.

Kolmogorov-Smirnov test was used to measure the normality of quantitative data. And based on its results, Student's *t*-test or Yeoman-Whitney test was used. Repeated measures ANOVA test (variance analysis) was employed to compare pain improvement in different periods. A chi-Squared test was applied to analyze the qualitative variables. SPSS 26.0 software (IBM Corp., Armonk, NY, USA) was used to analyze the data in the study. A significant difference was considered $p<0.05$.

Results

A total of 90 patients were included in the study. The average age of the patients was 72.5±10.9 years, (46-98 years). Among the studied patients, 21 (23.3%) were male, and 69 (76.7%) were female. 16 cases (17.8%) reported a history of corticosteroid use. 20 cases (22.2%) were current smokers. The mean volume of cement injected in patients was 5.8±1.2 cc, (3-11 cc). The mean percentage of cement distribution was 47.7±7.4% (30-64%). The mean pain score before surgery in the patients was 8.7±1.3 (score 4-10). The mean pain score 24 hours after the operation was 7.7±1.4 (score 4-10). The mean pain score 2 weeks after the operation in the patients was 4.8±1.3 (score 1-8). The mean pain score 6 weeks after the operation was 3.6±1.2 (score 1-7). The mean pain score 6 months after the operation was 3.5±1.4 (score 1-8).

The Kolmogorov-Smirnov test revealed that the distribution of quantitative data, including the age of patients and the percentage of cement distribution, is normal ($p>0.005$), and the rest of the studied variables were abnormal ($p<0.005$). The intensity of pain 24 hours after the operation had a significant positive correlation with the percentage of cement distribution (r=0.265, $p=0.012$) and the intensity of pain before the operation (r=0.455, $p<0.001$), while it was not significantly correlated with the age of the patients and the volume of cement. The intensity of pain 6 weeks after the operation had a significant positive correlation with the age of the patients (r=0.332, $p=0.001$) and the intensity of pain before the operation (r=0.255, $p=0.015$), but it was not found to be significantly associated with the percentage of cement distribution and cement volume (Table I and Figure 2).

The intensity of pain 6 months after the operation was positively correlated with the age of the patients (r=0.284, $p=0.007$) and negatively correlated with the percentage of cement distribution (r=-0.269, $p=0.010$). However, no significant correlation was found between pain intensity 6 months after the operation and cement volume and pain intensity before surgery (Table II and Figure 3).

Repeated variance test revealed that pain reduction significantly changed in 4 measured intervals ($p<0.001$). Although these changes in the measured time intervals were not significantly correlated with the variables of gender, smoking, history of using corticosteroids, and volume of injected cement ($p>0.05$), the reduction of pain was significantly associated with an increase in the percentage of cement distribution in the long-term period (Table III and Figure 4).

Discussion

Osteoporotic vertebral fractures are among the most common causes of disability in the elderly worldwide. Balloon kyphoplasty has been universally accepted for the treatment of osteoporotic vertebral fractures[16]. The current study aimed to compare the relationship of pain relief with the amount and distribution of injected cement in kyphoplasty for osteoporotic vertebral fractures.

In this study, the data of 90 patients with a mean age of 72.5±10.9 years were included in the study. The mean volume of cement injected was 1.2±5.8 cc, followed by the mean percentage of cement distribution (47.7±7.4%), the mean pain score before the operation (8.7±1.3), the mean pain score 24 hours after the operation (7.7±1.4), the mean pain score 2 weeks after the operation (4.8±1.3), the mean pain score 6 weeks after the operation (3.6±1.2) and the mean pain score 6 months after the operation (3.5±1.4) were evaluated after collection.

The results demonstrated that the pain intensity 24 hours after the operation had a significant positive correlation with the percentage of cement distribution and pain intensity before the operation, indicating that the intensity of pain increased 24 hours after the operation with the increase in the intensity of the pain before the operation and with the increase in the percentage of cement distribution. The intensity of pain 2 and 6 weeks after the operation was significantly correlated with the age of the patients and the intensity of the pain before the operation, where the intensity of the pain 2 and 6 weeks after the operation increased by the age of the patients and the increase of the pain intensity before the operation.

Table I. Distribution of the studied quantitative data.

		Age	Volume	Distribution	Pain before surgery	Pain after 24 hours	Pain after 2 weeks	Pain after 6 weeks	Pain after 6 months
N		90	90	90	90	90	90	90	90
Normal parameters[a,b]	Mean	72.57	5.889	47.717	8.70	7.76	4.86	3.64	3.53
	Std. Deviation	10.963	1.2825	7.4295	1.302	1.401	1.354	1.257	1.463
Most extreme differences	Absolute	.068	.143	.062	.202	.139	.165	.167	.147
	Positive	.050	.143	.061	.159	.139	.158	.155	.120
	Negative	-.068	-.135	-.062	-.202	-.136	-.165	-.167	-.147
Test statistic		.068	.143	.062	.202	.139	.165	.167	.147
Asymp. Sig. (2-tailed)		.200[c,d]	.000[c]	.200[c,d]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]

[a]Quantitative data are presented as mean and standard deviation. [b]Kolmogorov-Smirnov test was used to measure the normality of quantitative data. [c]ANOVA test (variance analysis) was employed to compare pain improvement in different time periods. [d]Student *t*-test or Yeoman-Whitney test was used for statistical analysis.

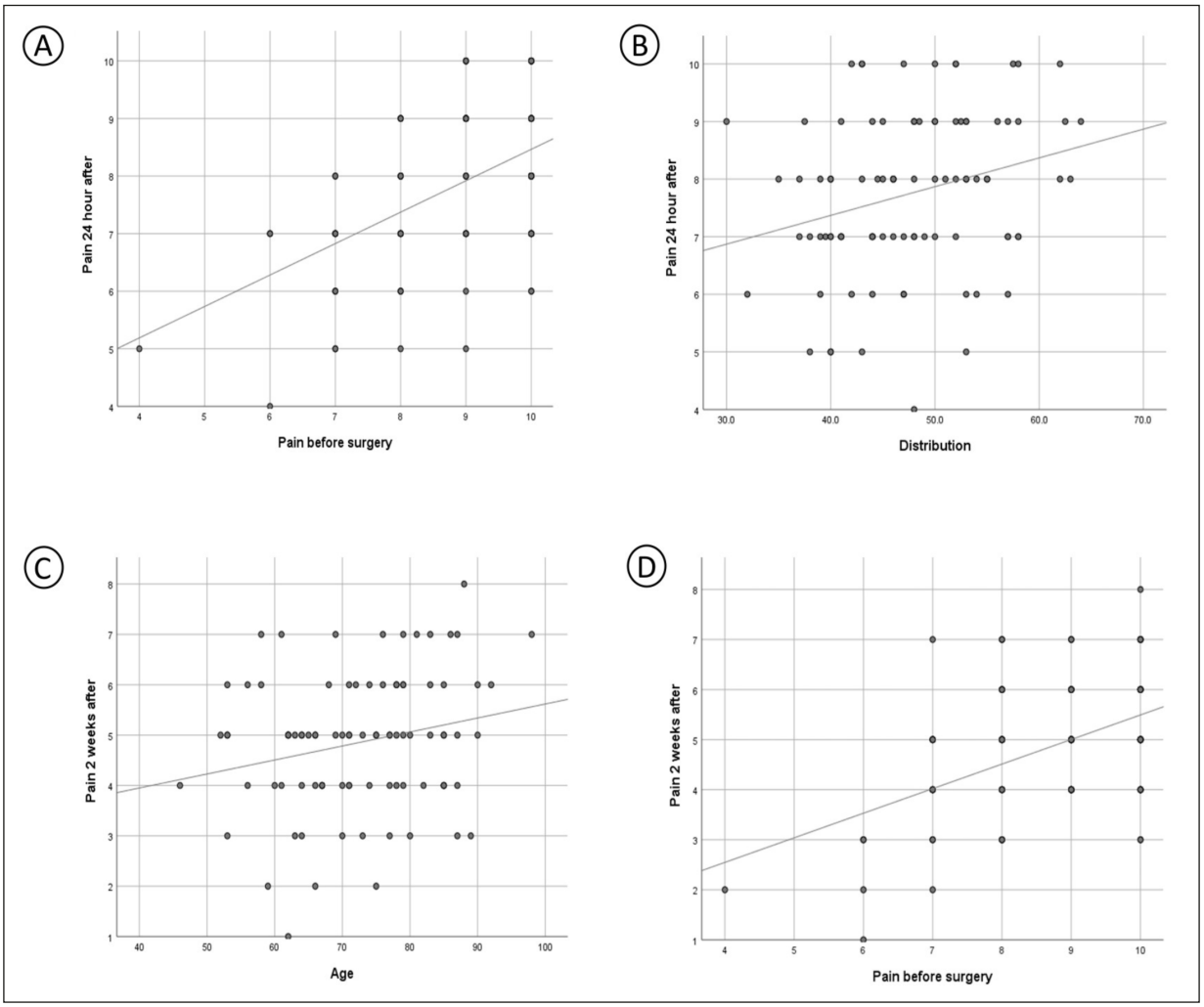

Figure 2. Correlation between preoperative and postoperative (24h) pain (**A**), patient distribution and postoperative (24h) pain (**B**), age and postoperative (2 weeks) pain (**C**), and preoperative and postoperative (2 weeks) pain (**D**).

Table II. Correlation of postoperative pain intensity in 4 time periods measured with age, cement volume, distribution percentage and preoperative pain intensity.

		Age	Distribution	Volume	Pain before surgery
Pain after 24 hours	R	0.178	0.265	0.235	0.455
	p-value	0.093	0.012	0.260	0.000
Pain after 2 weeks	R	0.225	0.077	0.840	0.373
	p-value	0.033	0.471	0.430	0.000
Pain after 6 weeks	R	0.332	-0.119	-0.073	0.255
	p-value	0.001	0.263	0.497	0.015
Pain after 6 months	R	0.284	-0.269	-0.180	0.140
	p-value	0.007	0.010	0.089	0.187

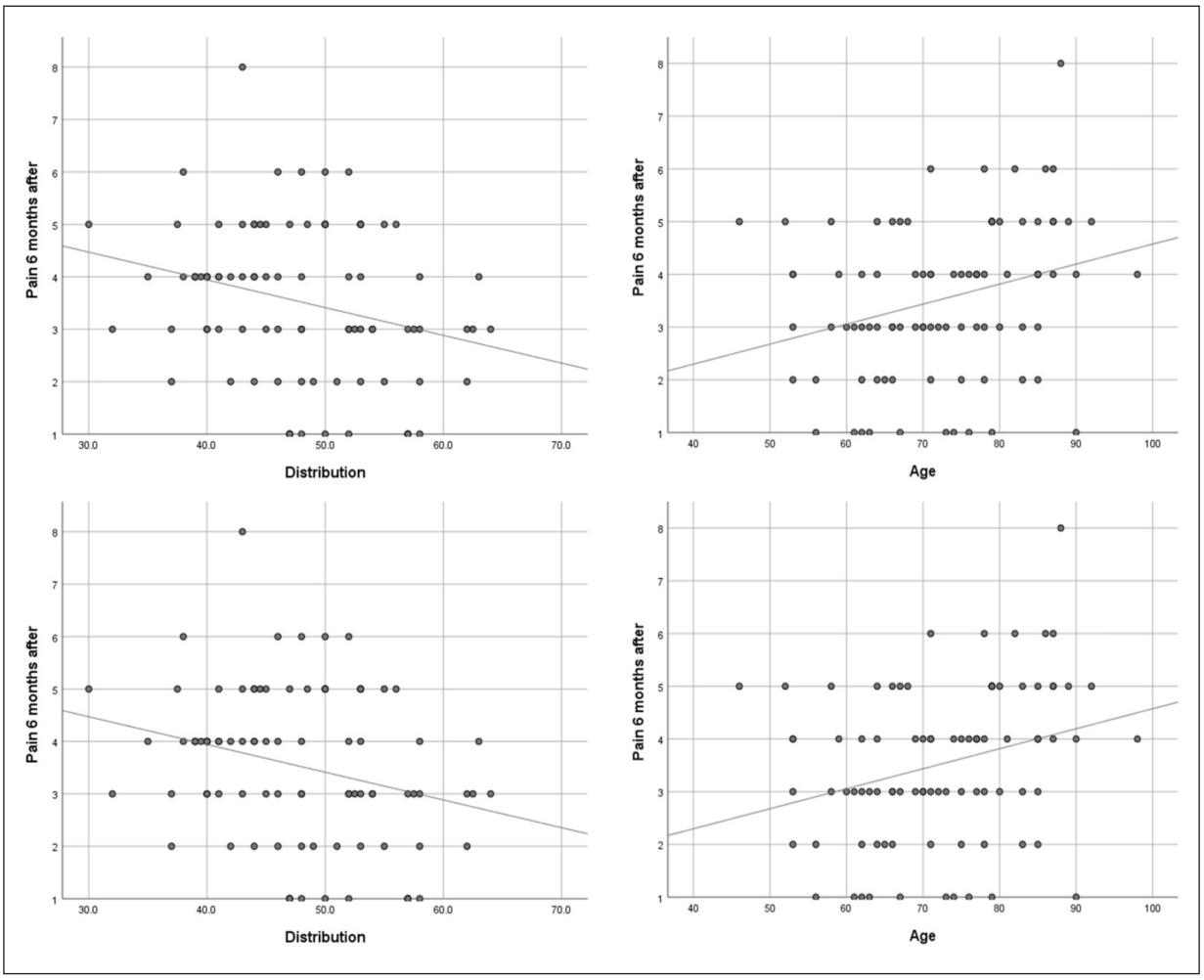

Figure 3. Correlation between pain 6 months after the operation with the age of patients and percentage of cement distribution.

The intensity of pain 6 months after the operation was positively correlated with the age of the patients and was negatively associated with the percentage of cement distribution, indicating that the pain intensity 6 months after the operation increased with the age of the patients and decreased by the increase of the percentage of cement distribution. Finally, the results demonstrated that the pain reduction has changed significantly in the 4 measured intervals after the kyphoplasty operation, and a significant improvement in the pain level of the patients has occurred continuously during a period of 6 months.

Table III. Pain intensity changes measured in 4 intervals.

Mauchly's Test of Sphericity						
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Epsilon		
				Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	.671	27.446	5	.798	1.000	.333

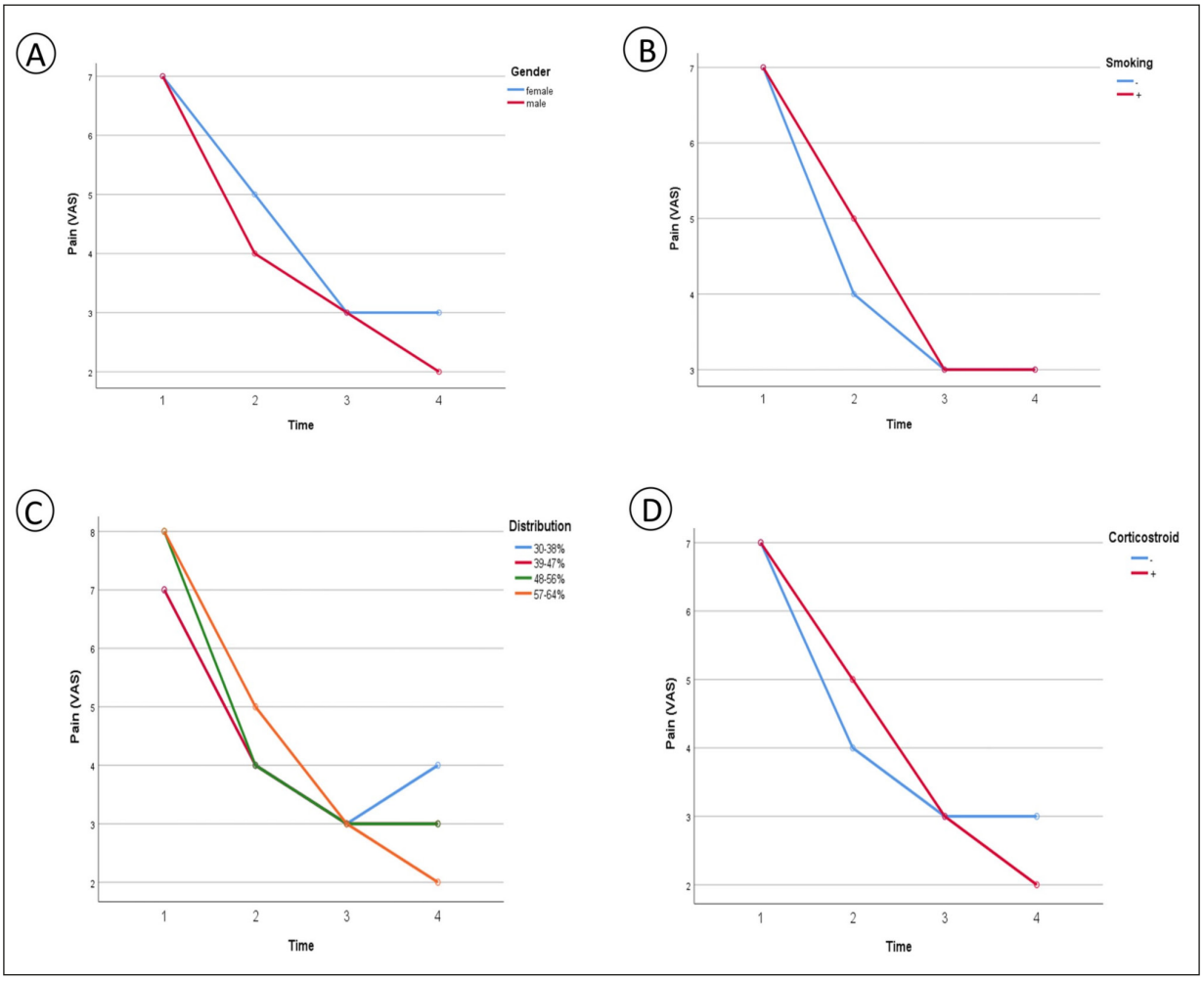

Figure 4. The trend of pain changes in 4 time periods measured according to gender (**A**), smoking (**B**), cement distribution, (**C**), and corticosteroid use (**D**).

Although this reduction in pain during the 6-month period was not significantly related to the variables of gender, smoking, history of corticosteroid use, and the volume of injected cement, which could be due to the small size of the study, such findings require additional studies. This amount of pain improvement has decreased significantly with the percentage of cement distribution, where the amount of pain improvement in the long-term period of the study increased with the increase of the percentage of cement distribution. It was found that the highest rate of pain recovery was related to the highest distribution percentage (57-64%) by dividing the distribution rate of cement into 4 groups.

The results of the present study showed that kyphoplasty was statistically associated with

significant improvements in pain up to 6 months after the operation. It seems that one of the most effective factors in the efficiency of kyphoplasty in these patients is the age of the patients. Older age was associated with poorer prognosis in patients, and older patients have poorer outcomes after kyphoplasty. As a result, it is better to offer kyphoplasty to patients who are candidates for this procedure in case of timely diagnosis.

The remarkable result of this study was that the volume of injected cement had no effect on the pain reduction of the patients after the operation, but the percentage of cement spread was associated with a better response in the patients. The reduction of pain after 6 months of kyphoplasty was statistically significant. Zapałowicz et al[17] reported that pain was reduced in 95.8% of patients compared to before kyphoplasty. The mean VAS score of patients before surgery was 6.54 and decreased to 0.26 at 12 months after surgery. The results of the mentioned study[17] are in line with the present study in terms of the effectiveness of this procedure in reducing the pain of patients. Ledlie et al[18] also examined a series of patients whose average VAS score before kyphoplasty was 8.6, and pain in the follow-up period of 3 and 12 months decreased to 2.1 and 1.4, respectively, confirming the results of the present study.

Improved pain relief after kyphoplasty has been confirmed by other studies[19,20], which is in line with the results of this study. Moreover, many studies[18-21,23] have shown that kyphoplasty has led to an increase in the quality of life in patients with vertebral fractures. Reduction of immobility after surgery, in turn leads to improvement of quality of life[19]. A study by Berenson et al[21] showed that patients undergoing kyphoplasty were likely to be at lower risk for subsequent fractures. In the present study, no new fracture occurred in any patient after 6 months.

Zhang et al[22] stated that more cement distribution around the upper and lower endplates was associated with a lower risk of recompression in patients undergoing percutaneous vertebroplasty. In the present study, the percentage of cement distribution was measured, but other patterns of cement distribution were not investigated. Lin et al[23] also showed that the percentage of cement distribution was associated with the bone cement volume, anterior vertebral height restoration rate (AVHRR), and BE occurrence. Their study was in line with our findings, where a higher percentage of cement distribution was related to decreased pain intensity.

Most studies[24,25] have concluded that there is no associated increased risk of new adjacent surface fractures in patients undergoing kyphoplasty. In a study of 726 patients, it was found that new fractures were relatively uncommon after kyphoplasty, and only half of these fractures occurred adjacent to previous kyphoplasty surfaces[18]. In the present study, no patient suffered a new fracture during the 6-month follow-up period.

Conclusions

Our data suggested that balloon kyphoplasty is a safe and successful method for treating symptomatic vertebral fractures. Kyphoplasty is associated with significant pain relief, improved quality of life, and kyphosis correction. The volume of cement injected had no effect on reducing patients' pain after the operation, but a higher percentage of cement distribution was linked to a better response in patients.

Conflict of Interest

The Authors declare that they have no conflict of interest.

Acknowledgments

Thanks to all participants in our study.

Ethics Approval

The study was approved by the Islamic Azad University of Medical Sciences with code IR.IAU.TMU.REC.1401.027.

Informed Consent

Written informed consent was obtained from each participant before the operation. Patients were informed about the risks and benefits of kyphoplasty surgery. Based on informed consent, patients who wanted to undergo kyphoplasty surgery were selected.

Funding

None.

Authors' Contributions

All authors drafted and revised the manuscript, and contributed equally to the study, including patient recruitment, data collection, and data analysis. All authors reviewed and approved the final version of the manuscript.

ORCID ID

Hesam Abdolhoseinpour: 0000-0002-6952-5353.

Availability of Data and Materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

References

1) Ahn SH, Park SM, Park SY, Yoo JI, Jung HS, Nho JH, Kim SH, Lee YK, Ha YC, Jang S, Kim TY, Kim HY. Osteoporosis and Osteoporotic Fracture Fact Sheet in Korea. J Bone Metab 2020; 27: 281-290.
2) Chen SJ, Liao WC, Huang KH, Lin CL, Tsai WC, Kung PT, Chang KH, Kao CH. Chronic obstructive pulmonary disease and allied conditions is a strong independent risk factor for osteoporosis and pathologic fractures: a population-based cohort study. QJM 2015; 108: 633-640.
3) Demirtaş Ö, Demirtaş G, Hurşitoğlu BS, Terzi H, Şekerci Z, Ök N. Is grand multiparity a risk factor for osteoporosis in postmenopausal women of lower socioeconomic status? Eur Rev Med Pharmacol Sci 2014; 18: 2709-2714.
4) Okyay DO, Okyay E, Dogan E, Kurtulmus S, Acet F, Taner CE. Prolonged breast-feeding is an independent risk factor for postmenopausal osteoporosis. Maturitas 2013; 74: 270-275.
5) Zhang J, Dennison E, Prieto-Alhambra D. Osteoporosis epidemiology using international cohorts. Curr Opin Rheumatol 2020; 32: 387-393.
6) Camacho PM, Petak SM, Binkley N, Diab DL, Eldeiry LS, Farooki A, Harris ST, Hurley DL, Kelly J, Lewiecki EM, Pessah-Pollack R, McClung M, Wimalawansa SJ, Watts NB. American Association of Clinical Endocrinologists/American College of Endocrinology clinical practice guidelines for the diagnosis and treatment of postmenopausal osteoporosis—2020 update. Endocr Pract 2020; 26: 1-46.
7) Johnell O, Kanis JA. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int 2006; 17: 1726-1733.
8) Mercurio M, Familiari F, de Filippis R, Varano C, Napoleone F, Galasso O, Gasparini G. Improvement in health status and quality of life in patients with osteoporosis treated with denosumab: results at a mean follow-up of six years. Eur Rev Med Pharmacol Sci 2022; 26: 16-23.
9) Lu LM, Ni XH, Ni JP, Tan W, Zhu XY, Yin S, Wu JS, Xu FC, Zhao QM. Clinical effect of unilateral balloon infusion of low dose bone cement in PKP for osteoporotic thoracolumbar compression fractures in the elderly. Eur Rev Med Pharmacol Sci 2022; 26: 3642-3647.
10) Garg B, Dixit V, Batra S, Malhotra R, Sharan A. Non-surgical management of acute osteoporotic vertebral compression fracture: A review. J Clin Orthop Trauma 2017; 8: 131-138.
11) Ameis A, Randhawa K, Yu H, Côté P, Haldeman S, Chou R, Hurwitz EL, Nordin M, Wong JJ, Shearer HM, Taylor-Vaisey A. The Global Spine Care Initiative: a review of reviews and recommendations for the non-invasive management of acute osteoporotic vertebral compression fracture pain in low- and middle-income communities. Eur Spine J 2018; 27: 861-869.
12) Ma X, Xia H, Wang J, Zhu X, Huang F, Lu L, He L. Re-fracture and correlated risk factors in patients with osteoporotic vertebral fractures. J Bone Miner Metab 2019; 37: 722-728.
13) 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.
14) Lieberman IH, Dudeney S, Reinhardt MK, Bell G. Initial outcome and efficacy of "kyphoplasty" in the treatment of painful osteoporotic vertebral compression fractures. Spine (Phila Pa 1976) 2001; 26: 1631-1638.
15) Tan L, Wen B, Guo Z, Chen Z. The effect of bone cement distribution on the outcome of percutaneous Vertebroplasty: a case cohort study. BMC Musculoskelet Disord 2020; 21: 541.
16) Abdolhoseinpour H, Rohde V, Akhavan-Sigari R. Pain Reduction by Percutaneous Vertebroplasty for Vertebral Compression Fractures with and without Intravertebral Clefts. J Complement Med Res 2020; 11: 11
17) Zapałowicz K, Radek M. Percutaneous balloon kyphoplasty in the treatment of painful vertebral compression fractures: effect on local kyphosis and one-year outcomes in pain and disability. Neurol Neurochir Pol 2015; 49: 11-15.
18) Ledlie JT, Renfro M. Balloon kyphoplasty: one-year outcomes in vertebral body height restoration, chronic pain, and activity levels. J Neurosurg Spine 2003; 98: 36-42.
19) Saxena BP, Shah BV, Joshi SP. Outcome of percutaneous balloon kyphoplasty in vertebral compression fractures. Indian J Orthopaed 2015; 49: 458-464.
20) Garfin SR, Buckley RA, Ledlie J. Balloon kyphoplasty for symptomatic vertebral body compression fractures results in rapid, significant, and sustained improvements in back pain, function, and quality of life for elderly patients. Spine 2006; 31: 2213-2220.
21) Berenson J, Pflugmacher R, Jarzem P, Zonder J, Schechtman K, Tillman JB, Bastian L, Ashraf T, Vrionis F; Cancer Patient Fracture Evaluation (CAFE) Investigators. Balloon kyphoplasty versus non-surgical fracture management for treatment of painful vertebral body compression fractures in patients with cancer: a multicentre, randomised controlled trial. Lancet Oncol 2011; 12: 225-235.
22) Zhang L, Wang Q, Wang L, Shen J, Zhang Q, Sun C. Bone cement distribution in the vertebral body affects chances of recompression after percutaneous vertebroplasty treatment in elderly patients with osteoporotic vertebral compression fractures. Clin Interv Aging 2017; 12: 431-436.

23) Lin J, Qian L, Jiang C, Chen X, Feng F, Lao L. Bone cement distribution is a potential predictor to the reconstructive effects of unilateral percutaneous kyphoplasty in OVCFs: a retrospective study. J Orthop Surg Res 2018; 13: 140.

24) Hirsch JA, Beall DP, Chambers MR, Andreshak TG, Brook AL, Bruel BM, Deen HG, Gerszten PC, Kreiner DS, Sansur CA, Tutton SM, van der Meer P, Stoevelaar HJ. Management of vertebral fragility fractures: a clinical care pathway developed by a multispecialty panel using the RAND/UCLA Appropriateness Method. Spine J 2018; 18: 2152-2161.

25) Venmans A, Klazen CA, Lohle PN, Mali WP, van Rooij WJ. Natural history of pain in patients with conservatively treated osteoporotic vertebral compression fractures: results from VERTOS II. AJNR Am J Neuroradiol 2012; 33: 519-521.