Bone and Arthrosurgery Science, 2026, Volume 4, Issue 1
http://ojs.bbwpublisher.com/index.php/BAS
Online ISSN: 2981-8222
Print ISSN: 3083-4856

Percutaneous Minimally Invasive Partial Resection of Vertebral Lesions Combined with Decompression and Percutaneous Vertebroplasty Injection for Thoracolumbar Metastatic Tumors

Yufei Wang[1†]*, Wenkai Jiang[2†], Jun Xu[1], Congcong Qin[1], Xinrui Wang[1], Hongfei Deng[2], Yaobin Ma[2]

[1]Department of Orthopedics, Linfen People's Hospital, Changzhi Medical College, Linfen 041000, Shanxi, China
[2]Graduate School of the First Clinical College, Changzhi Medical College, Changzhi 046000, Shanxi, China
[†]These authors contributed equally to this work and shared first authorship.

***Corresponding author:** Yufei Wang, sxlfzbf@163.com

Abstract: *Objective:* To explore the clinical efficacy and safety of percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and percutaneous vertebroplasty (PVP) in the treatment of thoracolumbar metastatic tumors. *Methods:* The clinical data of 54 patients with thoracolumbar metastatic tumors who underwent percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and PVP injection in our hospital from January 2020 to June 2024 were analyzed retrospectively. All patients received local anesthesia. There were 27 males and 27 females, including 31 cases of thoracic vertebral metastases, 18 cases of lumbar vertebral metastases, and 5 cases of thoracolumbar vertebral metastases. The Visual Analog Scale (VAS) score for pain and Oswestry Disability Index (ODI) before surgery and 1 week after surgery were compared. Meanwhile, the operation time, intraoperative blood loss, bone cement leakage, and other complications were recorded. *Results:* All patients successfully completed the operation. The operation time was 45–90 (67.89 ± 11.96) minutes, and the intraoperative blood loss was 30–100 (60.19 ± 20.16) mL. All patients were followed up for 3–12 months, with an average of 7.8 months. Except for 5 patients who experienced bone cement leakage, all other patients had their lesions healed smoothly, with no intraspinal leakage or other complications. The preoperative VAS score was 6–9 (7.69 ± 1.03) points, and the ODI was 51–79% (74.70 ± 7.64)%. One week after surgery, the VAS score was 1–3 (2.07 ± 0.70) points, which was significantly improved compared with that before surgery ($P < 0.05$). One week after surgery, the ODI was 24–41% (31.93 ± 4.43)%, which was also significantly improved compared with that before surgery ($P < 0.05$). *Conclusion:* Percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and PVP injection in the treatment of thoracolumbar metastatic tumors has the advantages of minimal invasiveness, effective relief of cancer-related pain, restoration of vertebral stability, and few complications, which is conducive to improving the quality of life of patients.

Keywords: Bone tumor; Percutaneous vertebroplasty; Decompression method; Thoracolumbar metastatic tumor

Online publication: March 11, 2026

1. Introduction

In recent years, percutaneous vertebroplasty (PVP) has been widely used in the treatment of patients with thoracolumbar tumors due to its minimally invasive nature, rapid pain relief, and quick recovery [1]. However, simple PVP may have problems such as insufficient decompression and increased risk of bone cement leakage in patients with large tumor burden, obvious posterior wall destruction, or mild nerve compression [2]. The comprehensive strategy of percutaneous minimally invasive partial resection of lesions combined with decompression followed by PVP injection can make up for the deficiencies of simple PVP treatment [3]. This method removes tumor tissue locally through a working channel, reduces vertebral pressure, and expands the safe space for bone cement injection. It not only reduces the risk of bone cement leakage but also achieves a certain degree of nerve decompression [4], which is considered a “bridging” minimally invasive treatment between simple PVP and open surgery. This study aims to further evaluate the clinical value of this comprehensive treatment strategy in pain control, neurological function improvement, and vertebral stability reconstruction by analyzing patients with thoracolumbar metastatic tumors who received percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and PVP injection, so as to provide data reference for clinical decision-making.

2. Data and methods

2.1. Case data

A retrospective analysis was conducted on the clinical data of 54 patients with thoracolumbar metastatic tumors who underwent percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and PVP injection in our hospital from January 2020 to June 2024. Patients were selected according to the following criteria: Inclusion criteria: (1) Vertebral metastatic tumors with only 1–2 segments; (2) Lesions located between the 10th thoracic vertebra and the 5th lumbar vertebra; (3) Presence of pathological fractures; (4) Patients refused open surgery or could not tolerate open surgery; (5) No obvious nerve injury; (6) Treatment strategy was partial resection of lesions combined with decompression and PVP injection; (7) Complete follow-up data were available. Exclusion criteria: (1) Multi-segmental vertebral metastatic tumors; (2) Lesions located above the 10th thoracic vertebra; (3) Simple PVP treatment was performed; (4) Complicated with infection or skin damage; (5) Incomplete follow-up data. A total of 54 patients were included according to the inclusion and exclusion criteria, including 27 males and 27 females, with an average age of 67.56 ± 11.43 years.

This study was approved by the Ethics Committee of Linfen People’s Hospital (Approval No. LFYy-2020-012). All patients provided written informed consent to participate in the study.

2.2. Anesthesia method

All patients underwent local anesthesia. After entering the operating room, an intravenous access was established, and monitors were connected. 10 mL of 2% lidocaine was mixed with 10 mL of normal saline to dilute the concentration to 1%. During the operation, indicators such as electrocardiogram (ECG), blood pressure (BP), heart rate (HR), oxyhemoglobin saturation (SpO_2), and end-tidal carbon dioxide partial pressure ($PETCO_2$) were monitored.

2.3. Surgical method

All surgeries in this study were performed by the same team of senior physicians. Surgical operation: After the patient was satisfactorily anesthetized, they were placed in the prone position, with pillows under the chest and hips. Under C-arm fluoroscopy, the affected vertebra was determined in the anteroposterior position, and the elliptical puncture points of the bilateral pedicles were identified. Routine disinfection and sterile draping were performed. Local infiltration anesthesia with 1% lidocaine was administered at the puncture points of the bilateral pedicles of the affected vertebra. At the puncture points of the bilateral pedicles of the affected vertebra, under the guidance of C-arm fluoroscopy, two disposable percutaneous puncture needles were inserted respectively into the lateral side of the midpoint of the anteroposterior elliptical projection of the pedicles of the affected vertebra. The C-arm fluoroscope was switched to the lateral position, and the puncture needles were gradually advanced into the pedicles to the posterior wall of the vertebral body. Under anteroposterior C-arm fluoroscopy, the puncture needles were seen to exceed the medial edge of the anteroposterior elliptical projection of the pedicles. The inner core of the puncture needles was removed, and guide wires were inserted. Dilators were replaced, the corresponding inner cores were taken out, and a disposable percutaneous puncture needle for biopsy was inserted along the guide wires to the posterior 1/4 of the vertebral body. The guide wires were pulled out, and the biopsy cannula was rotated slowly clockwise or the nucleus pulposus forceps under a single-channel spinal endoscope was used to remove the vertebral bone of the affected vertebra, so that the resected parts on both sides were connected, or a curved puncture cone for vertebroplasty was used to connect them. After irrigation with sterile water for injection (which flowed out from the opposite side), bone cement was mixed and loaded into a bone cement filler. The inner core of the disposable percutaneous puncture needle was removed, and the bone cement filler was connected to the disposable percutaneous puncture needle. Under C-arm fluoroscopy, an appropriate amount of bone cement was injected into the center of the affected vertebra through the disposable percutaneous puncture needle using the bone cement filler, and good diffusion of bone cement in the vertebral body was observed. After the bone cement solidified, the cannula of the percutaneous puncture needle was pulled out. Hemostasis was performed by compression for about 5 minutes. After confirming that the gauzes and instruments were correct, disinfection with povidone-iodine was performed, and the incision was covered with sterile dressings. Postoperative management: The patient maintained the prone position for 2–4 hours after surgery. After the bone cement was completely solidified, the patient could be turned to the supine or lateral position, and early sitting up was avoided (to reduce vertebral pressure). Vital signs, limb sensory and motor functions, and bleeding at the puncture site were monitored; Thoracolumbar X-ray was rechecked 24 hours after surgery to evaluate the position of bone cement and the effect of decompression. The patient could get out of bed with a brace 1–2 days after surgery (the brace was fixed for 3 months to maintain spinal stability).

Intraoperative precautions: Bilateral pedicle puncture was used during the operation, and the outer cannula of the puncture needle only needed to reach 1/4 of the anteroposterior diameter of the affected vertebra in the sagittal plane. The puncture angle was the normal puncture angle, and the transverse puncture angle could be adjusted according to the lesion. First, a part of the tissue could be removed with a biopsy instrument, and then multiple multi-angle intervertebral foramen endoscope nucleus pulposus forceps were used to resect the tissue in the lesion. As much tissue as possible was resected and removed towards the midline. The entire process was performed under C-arm fluoroscopy, and the depth of the small nucleus pulposus forceps was controlled at all times. The length of the affected pedicle and the vertebral puncture channel could be measured in advance. The diameter of the puncture needle could be 4.2 mm, which was conducive to lesion resection. The same method was used on the opposite side. If the resected lesions on both sides could not be connected during the operation, a curved puncture needle for vertebroplasty could be used to connect the two resected lesions. After connection, water column fluctuation could be observed on the opposite side during operation on the other side, or a simple pressure tester composed of the heads of two syringes inserted into the tail of the puncture needle cannula could be used for testing. Then, irrigation was performed with sterile water for injection, which was replaced with normal saline after irrigation. If the tumor tissue was not blood-rich, irrigation until clear was sufficient. First, bone cement was injected into one side of the lesion to make the bone cement fill the resected lesion as much as possible. During injection, the piston could be pushed back in the water column or syringe on the other side first, and the retracted volume was basically the same as the injected volume. Ideally, both lesions were completely filled by injection from one side without excessive diffusion into the vertebral bone tissue. The heat generated by the cement killed the tumor cells around the resected lesion cavity and strengthened the vertebral body. If the above goal could not be achieved, after the first injection, the side of the vertebral body not damaged by tumor cells was injected again, which could significantly reduce the patient's discomfort during the operation. During the operation, the scope of lesion resection should be controlled to avoid iatrogenic damage to the vertebral body. The puncture cannula beyond the posterior 1/4 of the vertebral body could avoid spinal cord injury during the operation. For blood-rich tumor tissue, although two puncture needles were used, the blood loss was not small, which could be performed under fluoroscopy.

2.4. Efficacy evaluation and follow-up

The Visual Analog Scale (VAS) score and Oswestry Disability Index (ODI) score of all patients before surgery and 1 week after surgery, as well as the preoperative and postoperative thoracolumbar imaging data of the patients, were followed up and recorded.

2.5. Statistical analysis

The operation time, blood loss, bone cement leakage, and other related complications of the patients were recorded. SPSS 27.0 software was used for analysis. Quantitative data were expressed as mean ± standard deviation (SD). Repeated-measures multivariate analysis of variance was used for the VAS score and ODI score before surgery and 1 week after surgery. If the data did not meet the sphericity assumption, the within-subject effect was based on the Greenhouse-Geisser corrected results. A P value < 0.05 was considered statistically significant.

3. Results

All patients successfully completed the operation. The operation time was 45–90 (67.89 ± 11.96) minutes, and the intraoperative blood loss was 30–100 (60.19 ± 20.16) mL. All patients were followed up for 3–12 months, with an average of 7.8 months. Except for 5 patients who experienced bone cement leakage, all other patients had their lesions healed smoothly, with no intraspinal leakage or other complications. The preoperative VAS score was 6–9 (7.69 ± 1.03) points, and the ODI was 51–79% (74.70 ± 7.64%). One week after surgery, the VAS score was 1–3 (2.07 ± 0.70) points, which was significantly improved compared with that before surgery ($P < 0.05$). One week after surgery, the ODI was 24–41% (31.93 ± 4.43%), which was also significantly improved compared with that before surgery ($P < 0.05$). See **Figures 1** to **4**.

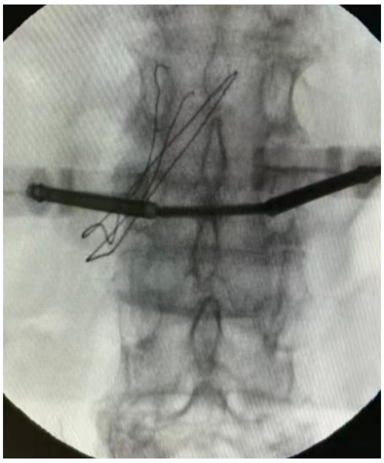

Figure 1. Anteroposterior view under intraoperative C-arm fluoroscopy

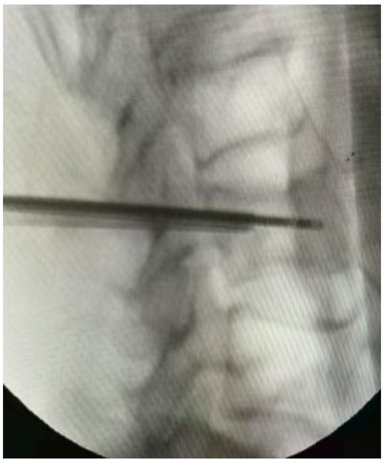

Figure 2. Lateral view under intraoperative C-arm fluoroscopy

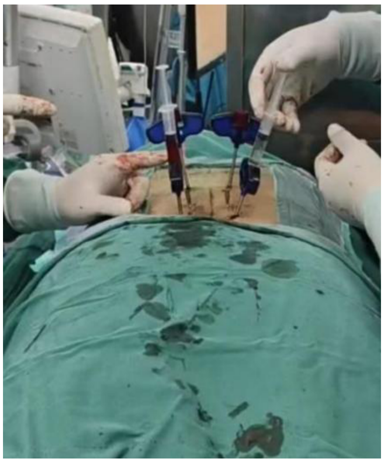

Figure 3. Irrigation with water for injection from one side and outflow from the opposite side during operation

Figure 4. Postoperative X-ray showing "dumbbell-shaped" bone cement

4. Discussion

The incidence of thoracolumbar metastatic tumors is increasing year by year [5]. Among them, the breast, prostate, and lung are the most common primary sites of thoracolumbar metastatic tumors [6]. It has been reported [7] that nearly 80% of patients with advanced breast cancer and prostate cancer [8] will develop bone metastases. Pain [9] is the most common manifestation of thoracolumbar metastatic tumors, mainly caused by vertebral destruction, pathological fractures, and nerve compression by the tumor. With the growth of the tumor, the patient's quality of life gradually decreases. How to quickly relieve pain, restore spinal stability, maintain neurological function, control tumor recurrence, and improve the quality of life has become a key goal of clinical treatment. As a minimally invasive treatment method [5,10], PVP is widely used in spinal diseases. The vertebral structure of osteoporotic vertebral fractures is different from that of metastatic tumors, so the choice of surgical plan is also different. To further clarify the differences between the two, the author supplements the pathological characteristics, pain mechanism, and PVP action mode of osteoporotic vertebral fractures. After osteoporotic vertebral fractures, the continuity of trabecular bone and vertebral cortex is often disrupted [11], secondary to intravertebral hemorrhage, leading to disorders of the original blood circulation microenvironment of the vertebral body. The pain is caused by vertebral instability, and the pain symptoms are particularly significant when the body position changes. However, in the supine or standing position, the vertebral body can obtain temporary mechanical support, and the pain is mostly relieved or disappears. This pain mechanism is consistent with the traumatic pain of limb fractures. After bone cement injection, on the one hand, the vertebral structure is strengthened [12] to restore vertebral stability; on the other hand, the heat generated by bone cement [13] destroys the nerve receptors at the fracture site to eliminate pain. During the injection process, bone cement diffuses along the loose trabecular bone spaces, and the space occupied by the original blood and a small amount of fat tissue in the vertebral body is filled by bone cement. The local blood circulation of trabecular bone is affected due to the extrusion of blood, but only the proportion of normal components such as bone tissue, blood, and fat is changed. The trabecular bone structure framework is still completely preserved, only showing a decrease in bone mass and density per unit volume.

There are essential differences in the vertebral destruction and pain mechanism between patients with thoracolumbar metastatic tumors and those with osteoporotic vertebral fractures. Their pain is due to the invasive destruction of the vertebral body and surrounding normal tissues by tumor tissue [14], rather than affecting vertebral stability. Therefore, there is no significant fluctuation in pain intensity when changing positions such as supine, standing, or other positions. Some patients can even relieve pain symptoms by appropriately adjusting their positions. The pain caused by such patients is mostly paroxysmal, with typical aggravation at night, which is closely related to the pathological process of continuous invasion of local tissues by tumor cells. Pathologically, metastatic tumor lesions are mostly characterized by bone destruction [15], accompanied by trabecular bone fracture and accumulation of a large amount of necrotic tissue. The trabecular bone structure in the central area of the lesion is more severely damaged and even completely replaced by tumor tissue. At the same time, the hemodynamic state in some tumor tissues is abnormally changed. Injecting bone cement into the vertebra involved by the tumor can not only strengthen the vertebra and generate heat energy to kill the tumor cells around the lesion by means of heat production [16], but the bone cement also occupies the original position of the tumor tissue instead of resecting or gasifying the tumor tissue. The original tumor tissue is squeezed into some surrounding tissues through the damaged trabecular bone pores around the lesion. These squeezed tissue components may enter the systemic blood circulation through the vertebral and paravertebral venous systems, posing a risk of tumor cell dissemination. If the puncture needle does not puncture the damaged tissue during the bone cement injection puncture process, it may increase the pressure in the lesion, aggravate the patient's discomfort during the operation, such as increased pain and severe distension, and accelerate the entry of tumor tissue into the blood. Even if the puncture needle directly punctures into the lesion, if the pressure in the vertebral body is not high, only a small amount of lesion contents containing blood and necrotic tissue will overflow. During the bone cement injection process, both the vertebral rod system and the injection system require the injection pressure to be greater than the outflow pressure to inject the bone cement into the lesion. Combined with the viscosity and hardness of the bone cement itself, more necrotic tissue and tumor tissue can quickly enter the blood circulation system, aggravating the occurrence of the patient's symptoms. Studies have shown [17] that the maximum temperature range of the anterior cortex when bone cement solidifies in the vertebral body is 44–113°C, and the maximum temperature range of the vertebral body center is 49–112°C, which is convenient for the bone cement to generate high heat to kill the surrounding tumor cells. However, only the cells around the bone cement mass are killed, and more tumor cells can still be squeezed into the surrounding tissues. Moreover, the killing effect on tumor tissue cells is limited by the duration of heat production and the temperature peak of the bone cement. It should be emphasized that vertebral destruction caused by metastatic tumors is mostly dominated by tissue invasion and does not cause severe fractures of the vertebral body, resulting in instability.

Bone cement injection is mostly suitable for osteolytic tumors [18], but it is difficult to implement during puncture or injection for osteoblastic tumors. Preoperative evaluation should be well performed, and there should be good experience in distinguishing osteoblastic tumors from osteoclastic tumors. Osteoblastic tumors [19] are more common in patients with breast cancer and prostate cancer. If bone cement is forced to be injected, the patient will have severe discomfort, and there will be very high pressure during the bone cement injection, which may be due to the small pores for bone cement diffusion. During the bone cement injection for osteoporotic fractures, bone cement leakage through the paravertebral venous system is often observed, and the leaked bone cement can even reach the lungs to cause pulmonary embolism [20]. It can be confirmed that if bone cement is simply used for injection in patients with vertebral metastatic tumors, the tumor tissue in the lesion can be pushed into the paravertebral venous system, accelerating the dissemination of tumor cells. For patients with vertebral bone metastases who refuse surgical resection or are physically unable to tolerate lesion resection surgery, the surgical method of percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and PVP injection is also an option. Percutaneous transpedicular partial resection of vertebral lesions and injection of bone cement into the vertebral body using decompression can avoid the above situations.

5. Conclusion

Percutaneous minimally invasive partial resection of vertebral lesions combined with decompression and PVP injection in the treatment of thoracolumbar metastatic tumors has the advantages of minimal invasiveness, effective relief of cancer-related pain, restoration of vertebral stability, and few complications, which is conducive to improving the quality of life of patients and provides a safe and effective minimally invasive treatment option for patients with thoracolumbar metastatic tumors. However, this study is a retrospective analysis with a small sample size and relatively insufficient experience. Lesions occurring above the 10th thoracic vertebra and involving multiple vertebrae cannot be treated. In the future, it is necessary to increase the sample size, accumulate operational experience, and carry out multi-center randomized controlled trials to verify the conclusions.

Funding

This work was supported by the Key Research and Development Program of Linfen City (No. 2329).

Disclosure statement

The authors declare no conflict of interest.

References

[1] Bao L, Shi G, Chen H, et al., 2024, Efficacy Analysis of Percutaneous Vertebroplasty in the Treatment of Advanced Upper Thoracic Vertebral Metastases. Chinese Journal of Spine and Spinal Cord, 34(12): 1283–1290.

[2] Linlin W, Jing F, Qianqian Y, et al., 2021, Computed Tomography-Guided Microwave Ablation Combined with Percutaneous Vertebroplasty for Treatment of Painful High Thoracic Vertebral Metastases. International Journal of

Hyperthermia, 38(1): 1069–1076.
[3] Cui Y P, Mi C, Yan T Q, et al., 2025, Safety and Efficacy of Minimally Invasive Small Incision Decompression Surgery for Thoracolumbar Metastatic Tumors. Chinese Journal of Spine and Spinal Cord, 35(01): 29–35.
[4] Zhu Y, Tang P, Zhang L M, et al., 2024, Survival Prognosis Analysis of Decompression and Separation Surgery for Thoracolumbar Metastatic Tumors. Journal of Practical Oncology, 39(05): 436–441.
[5] Zhou J, Dong J, 2025, Current Status and Prospect of Stability Reconstruction After Spinal Tumor Resection. Chinese Journal of Reparative and Reconstructive Surgery, 2025.
[6] Xiaojun Z, Jinchang L, Huaiyuan X, et al., 2020, A Comparative Study Between Minimally Invasive Spine Surgery and Traditional Open Surgery for Patients with Spinal Metastasis. Spine, 46(1): 62–68.
[7] Chen M, Zeng FY, Li QQ, et al., 2023, Meta-Analysis of the Efficacy of Technetium [99Tc] Methylene Diphosphonate Injection Alone and Combined with 89SrCl2 in the Treatment of Bone Metastases. China Oncology, 33(08): 751–767.
[8] Liang AN, Fan H, Xing JY, et al., 2025, New Progress in Precise Treatment of Tumor Bone Metastasis. Medical Journal of Peking Union Medical College Hospital, 16(04): 817–825.
[9] Skummer P, Chen N, Moroney J, et al., 2025, Abstract No. 593 Palliative Microwave Ablation for Painful Osseous Metastases. Journal of Vascular and Interventional Radiology, 36(3S): S208–S209.
[10] Han XL, Dang X, Zhang DA, et al., 2025, Efficacy and Safety of Microwave Ablation Combined with Percutaneous Vertebroplasty in the Treatment of Spinal Metastases. Journal of Practical Oncology, 40(11): 1822–1825.
[11] Wang YB, Kong QQ, Liu YG, et al., 2025, Efficacy of PMMA-Modified Bone Cement PVP "Tailing" in the Treatment of Recurrent Vertebral Fractures After OVCF PKP. Chinese Journal of Bone and Joint, 14(10): 865–870.
[12] Hu YC, Lun DX, 2025, Technical Exploration in the Treatment of Bone Tumors to Improve Clinical Treatment Level. Chinese Journal of Orthopaedic Surgery, 33(14): 1249–1251.
[13] Yang HH, Sun YL, Xiao R, 2022, Efficacy Observation of Radiofrequency Ablation Combined with Percutaneous Vertebroplasty in the Treatment of Spinal Metastases. Journal of Modern Oncology, 30(16): 2990–2994.
[14] Jiao CM, Yu H, Shi F, et al., 2012, Percutaneous Vertebroplasty Combined with Zoledronic Acid in the Treatment of Vertebral Metastatic Tumors. Biomedical Materials and Engineering, 9(03): 60–61.
[15] Chang HJ, Sangha A, Hyde D, et al., 2017, Positional Accuracy of Treating Multiple Versus Single Vertebral Metastases With Stereotactic Body Radiotherapy. Technology in Cancer Research & Treatment, 16(2): 231–237.
[16] Cui MH, Zhao WL, Xue N, 2016, Efficacy Observation of Vertebroplasty in the Treatment of Spinal Metastases. China Practical Medicine, 11(08): 93–94.
[17] Belkoff SM, Molloy S, 2003, Temperature Measurement During Polymerization of Polymethylmethacrylate Cement Used for Vertebroplasty. Spine, 28(14): 1555–1559.
[18] Jiang W, Lee S, Gan D, et al., 2025, Longitudinal Radiographical Changes Following Minimally Invasive Ablation and Cementoplasty of Osteolytic Vertebral Metastases: A Retrospective Study. HSS Journal, 2025: 15563316251346485.
[19] Xu Z, Yu YH, 2020, Research Progress in Radiotherapy for Spinal Metastases. Chinese Journal of Cancer Prevention and Treatment, 27(01): 80–84.
[20] Shen J, Chen K, Fu BY, et al., 2025, Research Progress of Bone Cement Pulmonary Embolism After Vertebral Augmentation. Chinese Journal of Orthopaedic Surgery, 33(20): 1879–1884.