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Three-field and four-field techniques of Three-Dimensional Conformal Radiotherapy (3DCRT) for lumber vertebral marrow metastasis treatment

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ABSTRACT

Background: The occurrence of metastases in the vertebral bone marrow is a palliative sign of malignant malignancies. This research aimed to compare the three-field and four-field techniques for 3D conformal radiation. The primary objective was to measure and compare the Conformation Index (CI), the Homogeneity Index (HI), and the Gradient Index (GI), as well as to investigate the radiation dosage absorbed by high-risk organs such as the spinal cord and kidneys.

Materials and Methods: Under the supervision of an oncologist, forty patients diagnosed with lumbar vertebral marrow metastasis tumors underwent CT simulation as part of their radiotherapy treatment. The acquired CT scans were then used with the Monaco v5.3 Treatment Planning System to generate delineations and treatment plans (TPS). Elekta's developed agility linear accelerator was used for the administration of radiotherapy. Two plan types were created for comparison: the three-field method and the four-field approach.

Results: The statistical analysis of lumber vertebral marrow metastatic tumors using the PTV 95%, PTV 105%, and PTV 2% criteria demonstrates that the four-field approach is better than the three-field technique. The four-field process delivers a higher maximum and means dosage to the tumor volume for PTVs of 95%, 105%, and 2%. However, the two systems have no substantial difference for the 95 percent PTV minimum dosage. These findings imply that the four-field method may be a more successful therapeutic option for individuals with malignancies that have spread to the spinal marrow. More study is required to verify these results and investigate other variables that may impact treatment outcomes. According to the findings of the investigation, the four-field approach was considerably superior to the three-field technique for the Homogeneity Index (HI) and Gradient Index (GI), while there was no significant difference for the Conformity Index (CI). Both approaches adhered to their designs. The research implies that the four-field strategy may be more successful at protecting the spinal cord, whereas the three-field technique protects the kidneys.

Conclusion: According to our results, the four-field strategy is more successful than the three-field technique in reducing radiation dosage to the spinal cord. In contrast, the three-field strategy is more successful than the four-field technique for protecting the kidneys. The four-field planning approach is superior for attaining a homogeneous dose distribution in the lumbar spinal bone metastases target volume.

Keywords: lumber spine, Homogeity Index (HI), Conformity Index (CI), 3-field technique, 4-field technique

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INTRODUCTION

External beam radiation therapy is one of the most prevalent treatments for painful bone metastases. In terms of pain relief, the effectiveness of radiation treatment varies between 50 and 80 percent [1]. Multiple publications, including randomized studies, meta-analyses, and recommendations, have discussed the optimal dose and fractionation required for durable palliation. The most common dosage schedules consist of 30 Gy in 10 fractions or 20 Gy in 5 fractions. A single 8 Gy fraction is as effective as more extensive treatment plans [2].

3-Dimensional Conformal Radiation Treatment (3DCRT) decreases the toxicity of radiation exposure to surrounding normal structures that is unneeded. As the Planning Target Volume (PTV) is not only enormous but also irregular in shape, it is challenging to develop an appropriate conformal plan that spares Organs at Risk (OAR) without compromising the PTV [3].

There are many techniques used to treat spinal cord tumors. The techniques used in this study where the first technique contains three fields one is anterior, and two other posterior fields are oblique. The second technique is the box technique, which includes four opposite fields. Spinal tumors are clumps of aberrant cells that form in or near the spinal column [4].

Every year, 3,000 and 10,000 new instances of intramedullary spinal cord tumors are diagnosed in every 100,000 persons. Ependymomas, the most common kind of spinal neuroepithelial tumor in adults, are uncommon. Astrocytomas make up just 6%-8% of intraspinal cancers overall. In children, however, 59% of all intramedullary spinal cord malignancies are caused by astrocyte tumors (also known as astrocytomas). In adults, ependymomas make up a more significant proportion of tumors than astrocytomas. High-grade or malignant tumors account for just 7%–25% of spinal cord astrocytomas in children and 10%-30% in adults [5].

Rades et al. examined the optimal radiotherapy treatment schedule for Metastatic Spinal Cord Compression (MSCC) in palliative situations, intending to minimize overall treatment time. In a prospective cohort, the study aimed to compare the outcomes of two different treatment schedules: 5 Gy × 5 Gy in 1 week and 10 Gy × 3 Gy in 2 weeks. After matching, 32 triplets

(N=96) were included in the analysis. The six-month Local Progression-Free Survival (LPFS) rates were 94% for the 5 Gy × 5 Gy group and 87% for the 10 Gy × 3 Gy group (p=0.36), while the six-month overall survival (OS) rates were 43% and 35%, respectively (p=0.74). Improvement in motor function was observed in 59% of patients in the 5 Gy × 5 Gy group compared to 34% in the 10 Gy × 3 Gy group (p=0.028), and overall response rates (combining improvement or no further progression of motor deficits) were 94% and 89%, respectively (p=0.71). Post-treatment ambulatory rates were 81% for the 5 Gy × 5 Gy group and 85% for the 10 Gy × 3 Gy group (p=0.61). Among non-ambulatory patients, 50% in the 5 Gy × 5 Gy group and 46% in the 10 Gy × 3 Gy group regained the ability to walk (p=1.00). The authors concluded that 5 Gy × 5 Gy in 1 week appeared to be similarly effective as 10 Gy × 3 Gy in 2 weeks. However, they noted that these results might not be generalizable to long-term survivors and should be validated in a randomized trial directly comparing the two treatment schedules [6].

This study aimed to compare the following indices for the two techniques (three field and four field techniques) of 3D conformal radiotherapy using the evaluation parameters Conformation Index (CI), Homogeneity Index (HI), and Gradient Index (GI), furthermore protecting the organs at risks such as spinal cord, and kidneys organ dose.

MATERIALS AND METHODS

This prospective clinical study was conducted in the oncology and radiotherapy center Al-Nasiriyah Teaching Hospital, Dhi-Qar, Iraq. The analysis was performed from December 2022 to May 2023. The Institute Review Board (IRB) of the Al-Nahrain University College of Medicine approved the study. The study involved 40 cases of lumber vertebral bone marrow metastasis patients. All patients were previously diagnosed by an oncologist and forwarded for a radiotherapy course. The inclusion criteria were patients with spinal cord tumors according to TNM classification at the age range (20–60) years. The exclusion criteria were patients with benign tumors and those who have osteoporosis.

The patients underwent Computed Tomography (CT) simulation using the Philips Somatom AS device. A specific CT scanning protocol captured the entire pelvic region for lumber vertebral bone marrow metastasis assessment. The slice thickness utilized during this scan was 0.3 cm.

The patients underwent irradiation utilizing the Synergy linear accelerator, which is manufactured by Elekta, a company based in Sweden. The treatment gantry of this device is equipped with 80 pairs of leaves forming a multileaf collimator, with each side containing 80 leave pairs. At the machine isocenter, the leaves have a resolution of 0.5 cm in width.

The first iteration of the plans was generated utilizing a three-field technique, while the second iteration employed a four-field method. This approach allowed for a thorough evaluation of the effects resulting from varying the number of treatment fields. This iterative approach provides valuable insights into optimizing treatment plans and assists in assessing the influence of different techniques on treatment outcomes, enabling clinicians to make informed decisions regarding the most suitable course of action for individual patients.

Following the importation of patient data, the radiation oncologist performed contouring, explicitly focusing on the Planning Target Volume (PTV). This process involved delineating the precise boundaries of the PTV to define the target area for radiation therapy accurately. Additionally, the radiation oncologist created additional PTVs at incremental distances of 1 mm, 2 mm, and 3 mm from the original PTV. These expanded PTVs allowed for evaluating potential variations in the treatment area, considering the uncertainties and margins related to patient setup, organ motion, and other relevant factors.

Three field technique

The initial step involved the creation of the first beam at a zero angle. This beam configuration served as the reference for subsequent beam arrangements. Following this, a duplicate of the original beam was generated, with modifications made to the angles. For the second and third beams, oblique angles were selected, specifically 140° and 210°. The decision to incorporate oblique angles in the second and third beams likely aimed to optimize the treatment plan by targeting the tumor from different directions and angles. This necessitates meticulous planning and evaluation to ensure optimal dose distribution while minimizing the dose to critical structures. The collimator angles were 90° for the beam with 140° angle, and the collimator angle was 270° sets for the third beam with an angle of 210°.

Four field technique

The four-field technique employed in this study shares similarities with the previously described three-field technique in terms of the initial steps. However, there are notable differences in the number of fields and angles utilized. Specifically, four beams were used for the four-field technique, corresponding to angles of 0°, 180°, 90°, and 270°, respectively. Notably, all the collimators' angles for each field or beam were zero. This configuration ensured the radiation beams were delivered perpendicularly to the treatment area, allowing consistent and uniform dose distribution.

Evaluation of the plan

In the context of Dose Planning (DP), it is necessary to modify the commonly used Conformity Index (CI), Homogeneity Index (HI), and Gradient Index (GI) for evaluating treatment plans. These indices, widely employed in routine clinical practice, were formulated initially based on the assumption of uniform dose prescription. However, for DP planning, modifications are required to account for variations in dose distribution.

The Homogeneity Index (HI), also called the uniformity index, is a valuable tool for evaluating the planned dose distribution within a target volume. It offers information regarding the uniformity of dose delivery within the target volume. Contrarily, dose conformity describes the degree to which the high-dose region aligns with the target volume, typically the Planning Target Volume (PTV) [7-9].

$$\mathrm{HI} = \frac{\mathrm{D2\%} - \mathrm{D98\%}}{\mathrm{D50\%}}$$

HI: Homogeneity Index
D2 %: is the absorbed dose in 2% of the isodose line
D98 %: is the absorbed dose in 98% of the isodose line
D50 %: is the absorbed dose in 50% of the isodose line

when the HI value is zero. This indicates that the absorbed-dose distribution is almost homogeneous. The number 1 means that the plan is not homogeneous.
The Conformity Index (CI) is specifically employed to evaluate the degree of conformal coverage of the PTV by the isodose volume prescribed in the treatment plan. It serves as a measure of the extent to which the prescribed isodose volume conforms to the PTV. An ideal treatment conformity is achieved when the CI value equals 1.

$$\mathrm{CI} = \frac{\mathrm{V_{PTV}} \times \mathrm{V_{TV}}}{\mathrm{TV_{PV}^2}}$$

CI: Conformity Index
VTV: volume of the actual prescribed dose
VPTV: volume of PTV
TVPV: volume of VPTV within VTV

The Gradient Index (GI) is a parameter that provides a quantitative measure of the dose gradient beyond the Planning Target Volume (PTV) and into the surrounding normal tissue structures. It is calculated by determining the ratio between the volume of half of the prescription isodose and the volume of the prescription isodose. In assessing the dose gradient beyond the PTV, the ratio known as the R50 percent (ratio of 50 percent prescription isodose volume to the planning target volume) has gained widespread acceptance as a benchmark. This ratio is represented by the equation below [10-13].

$$\text{Gradient Index (GI)} = \frac{\mathrm{V50\%}}{\mathrm{V100\%}}$$

While the Gradient Index (GI) and R50% have provided a means for quantitatively analyzing the dose gradient and facilitating comparisons between different treatment plans, they have certain limitations. These indices do not fully capture the complexity of the dose profile across the entire dose distribution range. Moreover, the current volume-based indices heavily rely on the target volume, which can lead to misleading results, mainly when dealing with small target volumes or intricate target shapes [14]. The GI and R50% offer valuable insights into the dose distribution characteristics beyond the PTV [15].
In DP planning, modifications to these indices are essential to account for the dynamic nature of dose delivery and variations in dose prescription. These modified indices enable a more accurate assessment of treatment plan quality and provide valuable insights into the adequacy of dose distribution within the target volume while preserving normal tissue sparing. The oncologist assesses the better plan for the patient, whether it is a three or four fields technique considering the patient's history and tumor status, and approves the plan.

Statistical analysis

The collected data was analyzed using the Statistical Packages for Social Sciences - version 28 (SPSS-28), a widely utilized statistical software package. The data were presented using various descriptive measures, including percentages, means, standard deviations, and ranges (minimum-maximum values). These measures allow for a comprehensive understanding of the data distribution and variability. The student T-test for the difference between three means was employed to assess the significance of differences between multiple means in quantitative data. This statistical test aids in determining whether the observed differences between groups are statistically significant. Statistical significance was established when the p-value associated with a particular test was equal to or less than 0.05.

RESULTS

The demographic distribution of the patients is shown in Table 1. The results show that the mean age of the patients included in this study is 54.64 years ± 3.85 years. The results show that the female 27 (67.5%) was more prevalent than the male 13 (32.5%), as shown in Figure 1. The weight of female 83.54 kg ± 32.36 kg patients is significantly higher than the male 72.53 kg ± 22.64 Kg at p–value 0.0353, as shown in Figure 2. The mean weight of all patients was 79.65 kg ± 456 kg. The mean lumber vertebral marrow metastasis tumor volume was 302.46 cm^3 ± 25.42 cm^3.

Tab. 1. Demographic distributions of patients with lumber vertebral marrow metastasis

Demographic names	Demographic values
Age (years)	54.64 ± 3.85
Gender	Male: 13 (32.5%)
	Female: 27 (67.5%)
Weight (Kg)	79.65 ± 456
Gender	Male: 72.53 ± 22.64
	Female: 83.54 ± 32.36
Tumor volume (cm^3)	302.46 ± 25.42

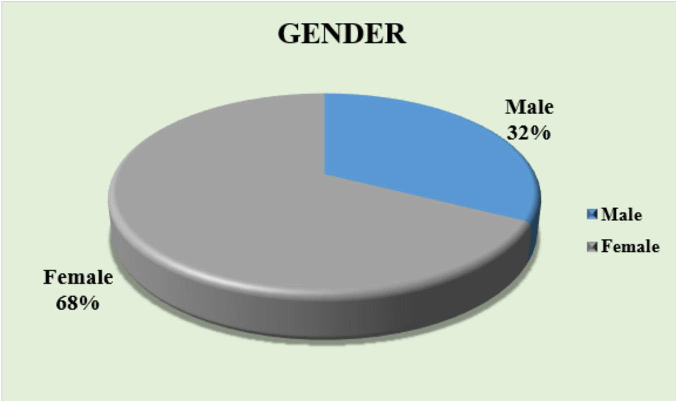

Fig. 1. Gender distribution of lumber vertebral marrow metastasis patients

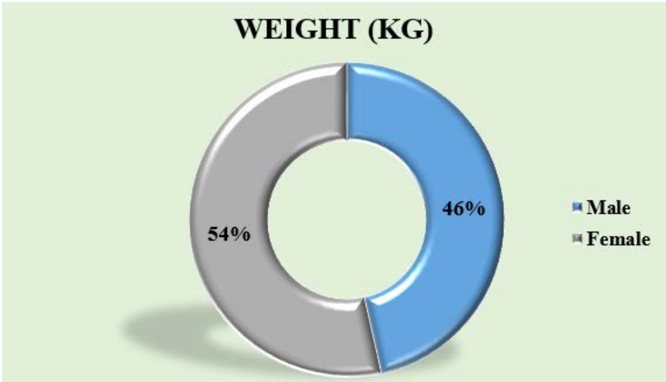

Fig. 2. Gender distribution for the weight of lumber vertebral marrow metastasis patients

The statistical analysis of lumber vertebral marrow metastasis tumors in three and four field techniques was presented in Table 2. The 95% coverage of the tumor volume (PTV 95%) was calculated with minimum, maximum, and mean dose in cGy, while the dose at 105% of the tumor volume (PTV 105%) represents the hot area. The PTV 2% represents the dose reached 2% of tumor volume, named the cold zone. The analysis shows that the four-field technique is significantly better than the three-field technique, where the four-field technique distributes more maximum and meaner dose to the tumor volume for PTV 95, PTV 105%, and PTV 2%, as shown in Figure 3-5, respectively. The minimum dose of the PTV 95% shows no significant difference between the two studied techniques.

Tab. 2. The lumber vertebral marrow metastasis tumor coverage for the three and four fields' techniques

Parameters	Three Field Technique	Four Field Technique	p-value
PTV 95%			
Minimum dose (cGy)	1690.9 ± 327.7	1747.3 ± 439.6	0.0539
Maximum dose (cGy)	2111.9 ± 637.5	2153.6 ± 520.9	0.0332*
Mean dose (cGy)	1998.6 ± 356.7	2033.3 ± 309.7	0.0043*
V105%			
Mean dose (cGy)	2249.05 ± 543.4	2305.5 ± 443.3	0.0148*
PTV 2%			
Mean dose (cGy)	40.9 ± 15.5	53.2 ± 13.8	0.0295*
* Significant difference at p-value ≤ 0.05.			

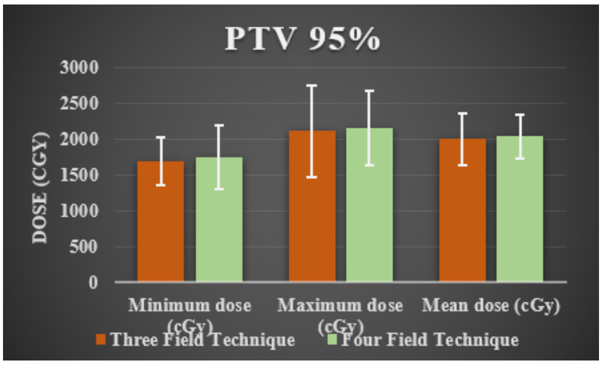

Fig. 3. Comparison of the dose coverage PTV 95% of the lumber vertebral marrow metastasis tumor between the three and four fields' techniques

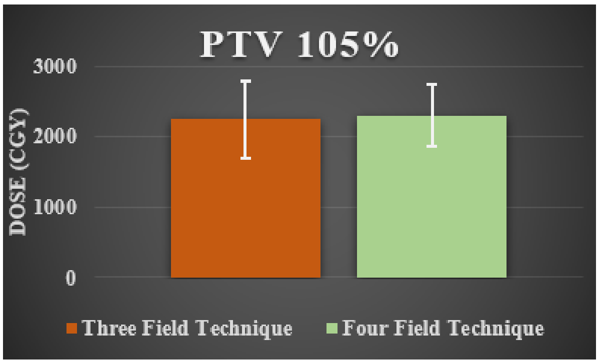

Fig. 4. Comparison of the hot are dose coverage PTV 105% of the lumber vertebral marrow metastasis tumor between the three and four fields' techniques

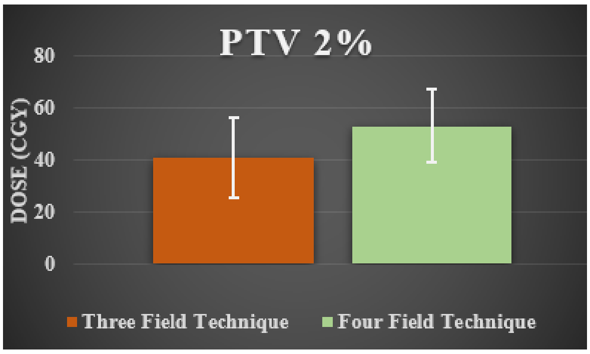

Fig. 5. Comparison of the cold area dose coverage PTV 2% of the lumber vertebral marrow metastasis tumor between the three and four fields' techniques

Evaluation parameters

An index was measured for all the methods in three and four fields' techniques to evaluate the efficiency of plans. These indexes are the Homogeneity Index (HI), Conformity Index (CI), and Gradient Index (GI). The resulting statistics of evaluation indexes are presented in Table 3. The analysis shows that the four field techniques had a significant difference better than the three field techniques for the Homogeneity Index (HI) and Gradient Index (GI), as shown in Figure 6 and 8, respectively. No significant difference was found in the Conformity Index (CI). The plans were conformal for both techniques, as shown in Figure 7.

Tab. 3. The lumber vertebral bone marrow metastasis tumor evaluation indexes for the three and four fields' techniques

Parameters	Three Field Technique	Four Field Technique	p-value
HI	0.59 ± 0.02	0.46 ± 0.07	0.0065*
CI	1.14 ± 0.05	1.05 ± 0.06	0.0589
GI	2.53 ± 0.94	2.94 ± 0.73	0.04433*
* Significant difference at p-value ≤ 0.05.			

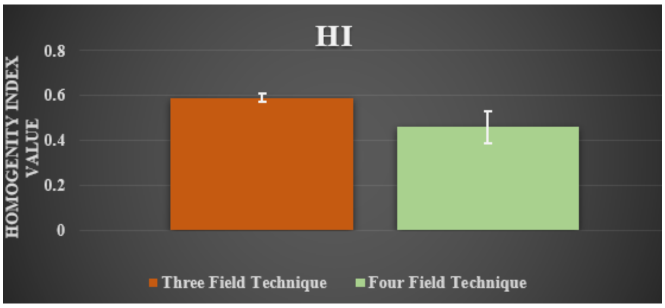

Fig. 6. Comparison of the Homogeneity Index (HI) for the lumber vertebral marrow metastasis tumor between the three and four fields' techniques

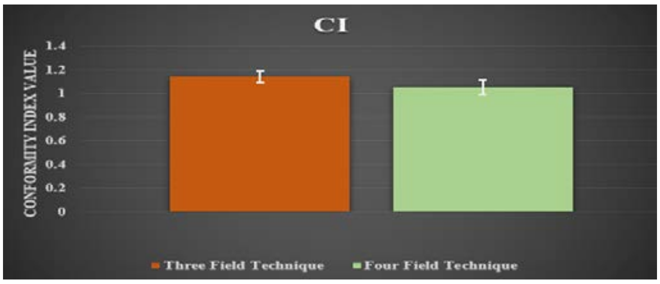

Fig. 7. Comparison of the Conformity Index (CI) for the lumber vertebral marrow metastasis tumor between the three and four fields' techniques

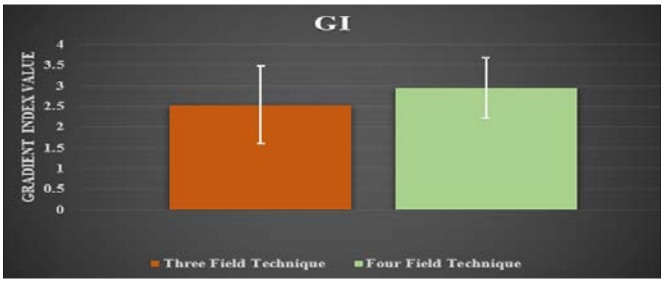

Fig. 8. Comparison of the Gradient Index (GI) for the lumber vertebral marrow metastasis tumor between the three and four fields' techniques

The results of Organs at Risk (OARs) in this study, such as the spinal cord and left and right kidneys were presented in Table 4. The results show that the right kidney volume is 133.554 cm^3 ± 16.44 cm^3, while the left is 157.38 cm^3 ± 14.07 cm^3. No significant difference was found between the volume of kidneys. The four-field technique protects the spinal cord significantly better than the three fields. The results show that the four-field method has a considerably lower dose than the three-field technique for the mean dose of the right and left kidneys. No significant difference was established for the minimum and maximum doses for the left and right kidneys.

Tab. 4. The organs at risk (OARs) for patients with lumber vertebral marrow metastasis

OARs	Three Field Technique	Four Field Technique	p-value
Spinal cord			
Maximum dose (cGy)	34.97 ± 6.35	30.54 ± 9.43	0.04741*
Right kidney			
Minimum dose (cGy)	67.5 ± 12.79	85.9 ± 22.3	0.05442
Maximum dose (cGy)	2045.2 ± 134.76	2062.9 ± 692.1	0.06958
Mean dose (cGy)	552.1 ± 29.57	1085.07 ± 448.6	<0.00001*
Left kidney			
Minimum dose (cGy)	53.7 ± 11.5	65.02 ± 7.08	0.0962
Maximum dose (cGy)	1947.1 ± 157.3	2011.6 ± 208.9	0.01402*
Mean dose (cGy)	322.3 ± 43.9	1001.9 ± 53.3	<0.00001*
* Significant difference at p-value ≤ 0.05.			

DISCUSSION

Radiation therapy is considered the primary therapeutic modality for spinal bone metastases, and uniform distribution of radiation dosage within the target volume is critical for ensuring favorable clinical outcomes [16].

Around 70% of individuals who pass away due to cancer have metastatic disease, with up to 40% of these patients experiencing spinal involvement. Spinal cord compression, which may occur in 5-10% of individuals with cancer, and up to 40% of those with pre-existing non-spinal bone metastases (over 25,000 cases per year), is becoming increasingly common as cancer patients live longer [17]. Breast and prostate cancers are the most frequent primary malignancies associated with such lesions. Patients with bone metastases from these types of cancer can have median survival times of several years, whereas contemporary series have shown mean survival times as short as six months for individuals with bronchogenic carcinoma [18].

The study examined the coverage of tumor volume at 95% (PTV 95%), the hot area at 105% of the tumor volume (PTV 105%), and the cold zone at 2% of the tumor volume (PTV 2%) of vertebral marrow metastasis tumors in the context of three and four field techniques The analysis considered the minimum, maximum, and mean doses in cGy.

The results indicate that the four-field technique offers significantly better outcomes than the three-field technique. Specifically, the four-field technique distributes a greater maximum and mean dose to the tumor volume for PTV 95%, PTV 105%, and PTV 2%. However, there is no significant difference between the two techniques regarding the minimum dose of PTV, 95%.

These findings have important implications for clinical practice, as they suggest that the four-field technique may be a more effective treatment option for patients with vertebral marrow metastasis tumors. The results highlight the importance of considering different treatment techniques and their impact on tumor volume coverage when developing treatment plans for these patients. Further research is needed to validate these findings and explore other factors that may influence treatment outcomes.

Radiotherapy has been a conventional treatment for relieving pain associated with lumbar metastases, and past research has focused on identifying the most effective dose-fractionation relationships for this modality. However, despite advancements in treatment planning technology, there is a lack of information on advanced field configurations for irradiating the lumbar spine. Our findings suggest that while both comparative plans can achieve similar coverage of the Planning Target Volume (PTV), the optimal dose distribution is associated with the 3-D plan developed explicitly for this purpose [19].

External beam radiation therapy has been a longstanding approach for managing bone metastases, particularly those affecting the spine. For many years, radiation oncologists have debated the optimal dose-fractionation schedules for such lesions. Retrospective studies and many randomized controlled clinical trials have fueled these debates. Interestingly, these trials have revealed that comparable levels of pain relief can be attained with both short and long courses of radiotherapy [20]. However, it is essential to note that radiation treatment prescriptions must include more than just the delineation of dosage, beam energy, and total and fractional dose notation. Further research is necessary to determine the most effective and appropriate course of radiation therapy for bone metastases.

Although extensive literature is available on the optimal dose-fractionation regimens for spinal metastases, there is limited information regarding the comparison of various techniques used in spine treatment. While many institutions have widely adopted advanced technologies such as stereotactic body irradiation, they may not be accessible to all users worldwide. Therefore, it is essential to conduct a formal assessment of more accessible technologies [21].

The analysis findings indicate that the four field techniques yielded significantly better results than the three field techniques for both the Homogeneity Index (HI) and Gradient Index (GI). This suggests that the four-field technique produces a more uniform dose distribution within the tumor volume and a steeper dose gradient outside the tumor volume than the three-field technique. However, no significant difference was found in the Conformity Index (CI), indicating that both methods were conformal, i.e., the treatment plans effectively conformed to the tumor volume.

These results have significant clinical implications, highlighting the importance of selecting the appropriate treatment technique to achieve the desired treatment outcomes. Using the four-field method may be more beneficial in cases where the homogeneity and gradient index are crucial factors in treatment success. However, either technique may be appropriate if conformity to the tumor volume is the primary goal. Further research is needed to validate these findings and explore other factors that may impact treatment efficiency.

Radiation oncologists are always concerned with the therapeutic index, which comprises both the efficacy and toxicity of treatment. Our study highlights the value of the three-dimensional conformal approach for spinal metastases as a palliative tool. However, several organs are at risk for radiation-related damage when treating the lumbar spine. Acute small bowel toxicity is a particular concern, as it can lead to diarrhea and other gastrointestinal complications [22]. For instance, Baglan et al. demonstrated that irradiation of more than 15 Gy to at least 150 cm^3 is associated with an incidence of grade 3 acute small bowel toxicity approaching 30%, according to the Common Toxicity Criteria scale (CTCS) [23, 24]. Similarly, Gunnlaugsson et al. found that the mean radiation dose at which diarrhea grade 2–3 occurred was 27 Gy [25].

Thus, when choosing a radiation therapy technique for spinal metastases, it is essential to balance treatment efficacy with each approach's potential risks and toxicities. While advanced techniques may offer superior dose distributions and improved outcomes, they may also carry a higher risk of toxicity, especially when treating sensitive organs such as the small bowel. Therefore, it is essential to conduct further research to determine the optimal radiation therapy techniques for spinal metastases that balance efficacy and safety in various patient populations [26].

The study results regarding the Organs at Risk (OARs), such as the spinal cord, left kidney, and right kidney. The findings show that the volume of the right kidney is 133.554 $cm^3 \pm 16.44$ cm^3, while the volume of the left kidney is 157.38 $cm^3 \pm 14.07$ cm^3, with no significant difference between the two kidneys.

Furthermore, the results indicate that the four-field technique provided significantly better protection to the spinal cord than the three-field technique. The four-field technique resulted in a lower dose to the left and right kidneys than the three-field technique, as indicated by the mean dose results. However, no significant difference was observed between the two techniques regarding the minimum and maximum doses for the left and right kidneys.

These findings suggest that the four-field technique may be a more appropriate treatment option in cases where the protection of the spinal cord and kidneys is crucial, particularly when compared to the three-field technique. Further studies are required to confirm these results and explore other factors that may influence the efficacy of treatment plans for OARs. Overall, the results of this study emphasize the importance of selecting the appropriate allowed us to investigate the safety and feasibility of conformal 3D radiation techniques while also considering potential adverse effects on the kidneys.

In contrast, the percentage of the area covered by >95% radiotherapy dose in the vertebral body, which is the critical part of the vertebrae for fractures and cord compression, was low and suboptimal in three field planning. The maximum doses were high, but tolerance ranges at palliative doses within the normal tissue. Suboptimal doses may temporarily relieve pain but do not help stop disease progression. To achieve the intended doses in a three fields technique, it is necessary to calculate the exact depth of the vertebrae [28-29].

Radiotherapy is the primary treatment for spinal bone metastasis, and achieving a homogenous dose distribution in the target volume is crucial for successful treatment outcomes.

According to the International Commission on Radiation Units and Measurements (ICRU) report, a homogenous dose within 95% to 107% of the prescribed dose is recommended for the target volume, with a variation of ± 10% from the prescribed dose widely used in clinical practice [30].

The results of Nehru et al. were comparable to those of other studies. According to a survey by Fundagul Andic in Turkey, parallel opposed AP/PA field achieved the intended dose ranges with a homogenous dose distribution and reasonable doses to the medulla spinalis, esophagus, and intestines. Investigating the relationship between radiotherapy technique and treatment treatment technique to minimize the risk of OAR damage and maximize treatment efficacy.

One of the potential drawbacks of utilizing conformal 3D radiation techniques that employ a paired set of oblique wedged fields is the possibility of increased radiation doses being deposited within the kidneys. The potential risks of radiation-induced kidney damage have been extensively reviewed and summarized by Dawson et al. In particular, they identified a dose range associated with a 5% risk for toxicity at five years, which fell between 18 Gy to 23 Gy, irrespective of the fractionation scheme utilized [27]. In light of these established criteria, we conducted a comparative evaluation to assess the potential for renal damage from radiation treatment. This analysis outcome would provide important information, particularly for patients with long life expectancies [31].

According to our findings, the four-field technique is more effective in reducing radiation dose to the spinal cord compared to the three-field technique. On the other hand, the three-field technique is more effective in protecting the kidneys than the four-field technique. Our study's results suggest a trade-off between protecting the spinal cord and kidneys, and the choice of technique should be tailored to the individual patient's needs and medical history. Further studies are necessary to evaluate the long-term effects of these techniques on the spinal cord and kidney function, as well as other organs at risk.

CONCLUSION

In conclusion, the four-field technique provided a greater maximum and mean dose to the tumor volume for PTV 95%, PTV 105%, and PTV 2%. This study compared the effectiveness of the three-field and four-field techniques for treating vertebral marrow metastasis tumors. The homogeneity and gradient indexes were significantly better for the four-field technique, while there was no significant difference in the conformity index. The four-field technique was also found to be more effective in reducing radiation dose to the spinal cord, while the three-field technique was more effective in protecting the kidneys. This study suggests that the choice of technique should be tailored to the individual patient's needs, and further studies are necessary to evaluate the long-term effects on organ function.

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