RESEARCH ARTICLE

Quality Of Life and Functional Outcomes in Patients with Spinal Metastatic Bone Disease: A Retrospective Observational Study

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Abstract

Objectives: Spinal tumors account for 6-8% of all bone tumors, with spinal metastatic bone disease being the most commonly found spinal tumor. Patients with spinal metastatic bone disease typically present with symptoms such as pain, neurological impairments, and potential paralysis. The morbidity associated with spinal metastatic bone disease significantly impacts the patients' quality of life. This study aims to investigate the outcomes of quality of life and functional outcomes in patients with spinal metastatic bone disease.

Methods: A retrospective observational study was conducted involving patients with spinal metastatic bone disease treated at Dr. Cipto Mangunkusumo Hospital from January 2021 to December 2023. The functional outcomes in this study were assessed using the Short Form-36 (SF-36) and the Oswestry Disability Index (ODI).

Results: A total of 73 patients were included in this study, with breast cancer being the most common primary tumor (53%). Significant associations were found between gender and pain component ($P = 0.045$) and general health component ($P = 0.047$) of SF-36 scores. Significant differences were also observed in SF-36 components - physical functioning ($P = 0.046$, $r = -0.562$), energy/fatigue ($P = 0.035$, $r = -0.621$), and general health ($P = 0.027$, $r = -0.513$) with age. Significant differences were observed between pre-therapy and post-therapy in SF-36 scores for physical functioning, role limitations due to physical health, energy/fatigue, pain, general health, and ODI. Post-surgery, SF-36 role limitations due to physical health and ODI scores showed significant improvement. No significant relationships were found between pain severity, extremity weakness, type of therapy, and SF-36 or ODI scores.

Conclusion: There are significant associations between gender, age, and functional outcomes in patients with spinal metastatic bone disease. There is improvement in SF-36 scores and ODI scores post-therapy, especially after surgery.

Level of evidence: III

Keywords: Oswestry disability index, SF-36, Spinal metastatic bone disease

Introduction

Spinal metastatic bone disease poses significant challenges for patient outcomes, quality of life (QoL), and treatment strategies. These tumors, which spread from primary cancers, often cause spinal cord compression, pain, neurological impairment, and loss of function.[1] Managing these problems requires a multidisciplinary approach that combines oncological control with symptom relief and preservation of daily activities.[2] Surgical procedures such as total en bloc spondylectomy have been studied in both primary malignant bone tumors and solitary spinal metastases. The goal of these operations is to improve oncological outcomes and maintain spinal stability.[3] In addition to surgery, interventions such as epidural steroid injections are used to control cancer-related pain, showing the importance of addressing both tumor burden and symptom management.[4]

Recent advances in diagnostic imaging, particularly

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molecular imaging, provide more accurate characterization of spinal tumors. Advancements in diagnostic techniques, such as molecular imaging, have enabled more precise tumor characterization, prediction of treatment response, and differentiation of viable tumor tissue from necrotic areas in spinal tumors.[5] Less invasive options, such as percutaneous procedures, have also been studied for their safety and effectiveness.[6] Long-term follow-up studies have evaluated the survival and health-related quality of life in patients, highlighting the importance of monitoring outcomes beyond the immediate post-treatment period to assess the holistic impact of interventions on patients' lives.[7] In this context, understanding prognostic factors, risks for disability, and functional outcome in spinal metastatic bone disease is essential for planning treatment.[8] Various options, including vertebrectomy, radiotherapy, and chemotherapy, have been evaluated to improve survival, reduce symptoms, and enhance patient well-being.[9,10]

Our research question was: What prognostic factors are associated with disability and functional outcomes in patients with spinal metastatic bone disease, and how do different treatments influence their quality of life.

Materials and Methods

Study Design

This was a retrospective, observational investigation of changes in the QOL and disability of patients with spinal metastatic bone disease.

Patients

We included patients with histopathologically confirmed malignant tumor metastasis to the spine receiving management in the form of surgical procedures, and/or radiotherapy, and/or chemotherapy from January 2021 to December 2023 in our center. Patients with primary spinal tumors (non-metastatic), cognitive impairments affecting the ability to participate in assessments, severe comorbidities that may significantly impact quality of life and functional outcomes, a history of significant spinal trauma unrelated to the current malignant spinal tumor, and a history of major spinal surgery within a certain timeframe that may confound the study results were excluded from this study. Preoperative details regarding pain severity and neurological status (motor weakness, sensory loss, or sphincter involvement) were recorded, as these factors strongly influence postoperative outcomes and guide treatment decisions.[11]

Parameters

Patients' age, sex, pain, weakness of the extremity, type of surgery, QOL based on the 36-Item Short Form Survey (SF-36), and Oswestry Disability Index (ODI) were investigated. Preoperative information on pain severity and patients' neurological status was recorded in this study. All patient-reported outcome measures used in this study were self-assessed or self-administered questionnaires.[11-13]

Measurement of Pain

We measured pain parameters through a Visual Analog Scale (VAS). The VAS consists of 10 10-point grading scale with clear pain descriptors at its ends, from "no pain" to "worst pain imaginable." The patient then self-assessed and marked the intensity of their pain, enabling the measurement of this distance in millimetres. Interpretation of these values is contextual, with higher readings indicating greater pain severity.[11]

Measurement of SF-36

The SF-36 is a self-reported questionnaire comprising 36 items that assess various aspects of health-related quality of life. The questionnaire covers 10 health domains: physical functioning, role limitations due to physical health problems, bodily pain, general health perceptions, vitality, social functioning, and role limitations due to emotional problems, emotional well-being, and health change. Each SF-36 domain was scored separately on a scale from 0 to 100, with higher scores indicating better perceived health status. We interpreted the individual domain scores within the context of the study or clinical setting. Higher scores indicated better quality of life in that domain, while lower scores might indicate areas of concern that need attention.[12]

Measurement of ODI

The ODI is a self-administered questionnaire consisting of 10 sections that assess different aspects of disability related to low back pain. Each section represents a different daily life activity or functional task that may be affected by back pain. Patients are asked to choose one statement in each section that best describes their situation. Each section in the ODI is scored on a scale of 0 to 5, where 0 indicates no disability and 5 indicates maximum disability. The scores from the chosen statements in all sections are totalled to determine a percentage score.

The total score is converted into a percentage disability score using a specific formula. The higher the percentage, the greater the perceived disability due to low back pain. The ODI score indicates the level of disability an individual experiences. Lower scores represent less disability, while higher scores indicate more severe disability.[13]

Data Analysis

Data were collected in raw form, systematically organized, and analyzed using the International Business Machines Statistical Package for the Social Sciences (IBM SPSS) version 24.0. The results were presented and clarified in terms of proportions and percentages. The significance level used was 5% (0.05) with a tendency significance level of 20% (0.2).

Subsequent analysis was carried out as follows:

a) Describing the demographic characteristics of subjects with spinal metastatic bone disease. The aim was to provide an overview of the research data.
b) Describing the quality of life outcomes of patients with spinal metastatic bone disease.
c) Describing the functional outcomes of patients with spinal metastatic bone disease.
d) Assessing the differences in quality of life and functional outcomes of patients with spinal metastatic bone disease who received chemotherapy, radiotherapy, and/or surgery.

Univariate analysis was conducted to determine the general characteristics of the research sample. Categorical data, such as sex and VAS scores, are presented as proportions and percentages. Numerical data, such as SF-36 and ODI scores, are presented as means and standard deviations when the data are normally distributed. Statistical analysis was performed on numerical data, including normality tests using the Shapiro-Wilk test for samples of fewer than 30 subjects or the Kolmogorov-Smirnov test for samples of 30 or more. Data was considered normal if P>0.05. This was followed by bivariate analysis. For categorical data, the Chi-square test was used. For numerical data, if the data obtained followed a normal distribution, the analysis would employ a one-way Analysis of Variance (ANOVA). Conversely, if the data obtained did not follow a normal distribution, the analysis used the Kruskal-Wallis test. The comparison test was considered significant if the p-value was less than 0.05.[14]

Results

Patients' Characteristics

The total number of subjects in this study was 73 individuals. The overall mean age of the patients was 51.2 years with a standard deviation of 14.2 years. The youngest subject was 30 years old, and the oldest was 85 years old. 69.9% of the subjects were female. The observed complaints in this study included pain and weakness or paralysis [Table 1].

Table 1. Characteristics and demographic distribution of the research subjects

Variables	N (%)
Age*	Mean 51± SD 14
Gender	
Female	51(70%)
Male	22(30%)
VAS	
Without pain	22 (30%)
Mild pain	12 (16%)
Moderate pain	33 (46%)
Severe pain	6 (8%)
Extremity weakness	
Not present	37 (51%)
Present	36 (49%)
Therapy	
Chemotherapy and Radiotherapy	37 (51%)
Chemotherapy	12 (16%)
Chemotherapy, Radiotherapy, and Surgery	11 (15%)
Radiotherapy	7 (9.6%)
Chemotherapy and Surgery	3 (4.2%)
Radiotherapy and Surgery	3 (4.2%)
Surgery	0 (0)

*Normality test using Kolmogorov-Smirnov test

The treatments received by the patients were categorized into single therapies (chemotherapy, radiotherapy, or surgery) and their combinations [Table 1]. The distribution of primary tumors is shown in [Table 2]. Nevertheless, in this study, open decompression surgery and posterior stabilization were found to be the most common type of spinal surgery, with a total of 10 subjects (59%) [Table 3].

Table 2. Distribution of Primary Tumors

No	Primary Tumor	N	Percentage (%)
1	Ca Mammae	39	53
2	Ca Nasopharyngeal	8	11
3	Ca Pulmonary	6	8.2
4	Ca Prostate	6	8.2
5	Intracranial mass	3	4.1
6	Ca Cervical	2	2.7
7	Ca Liver	1	1.4

Table 2. Continued

8	Ca Renal	1	1.4
9	Ca Thyroid	1	1.4
10	Ca Rectum	1	1.4
11	Ca Rectosigmoid	1	1.4
12	Neuroendocrine tumor	1	1.4
13	Neuroblastoma	1	1.4
14	Ca Ureteral	1	1.4
15	Malign orbital melanoma	1	1.4
	Total	73	100%

Table 3. Distribution of surgical interventions for the spine tumors

No	Surgical Interventions	N	Percentage (%)
1	Open Decompression by laminectomy Posterior Stabilization	10	59
2	Vertebroplasty	4	24
3	Anterior cervical corpectomy and fusion	2	11
4	Selective Nerve Root Block (SNRB)	1	6.0
	Total	17	100%

Relationship Between Variable and Post-Therapy SF-36 Scores and ODI Scores

Tables 4-8 present the bivariate analyses of the variables studied in this research, focusing on outcomes in terms of SF-36 and ODI scores. Subsequent bivariate analysis showed no significant differences in extremity pain or weakness complaints among patients and the type of therapy used, as measured by SF-36 and ODI component scores [Table 4-8].

Table 4. The Relationship Between Gender and Post-Therapy ODI Scores

Variables	Gender		*P**
	Male	***Female***	
Component I: Physical Functioning	80 (20-100)	75 (20-100)	0.762
Component II: Role Limitations Due to Physical Health	75 (50-100)	75 (50-100)	0.884
Component III: Role Limitations Due to Emotional Problems	67 (33-100)	100 (33-100)	0.359
Component IV: Energy/Fatigue	90 (60-100)	90 (55-100)	0.345
Component V: Emotional Well-Being	92 (80-100)	90 (60-100)	0.237
Component VI: Social Functioning	88 (63-100)	88 (50-100)	0.791
Component VII: Pain	92 (55-100)	75 (43-100)	0.045
Component VIII: General Health	90 (55-100)	75 (40-100)	0.047
Component IX: Health Change	75 (25-100)	75 (0-100)	0.919
ODI Score	3.5 (1-15)	4 (1-24)	0.333

Table 5. The Relationship Between Age and Post-Therapy ODI Scores

Variable	P*	r
Component I: Physical Functioning	0.046	- 0.562
Component II: Role Limitations Due to Physical Health	0.893	0.016
Component III: Role Limitations Due to Emotional Problems	0.976	0.004
Component IV: Energy/Fatigue	0.035	-0.621
Component V: Emotional Well-Being	0.426	0.095

Table 5. Continued

Component VI: Social Functioning	0.736	0.040
Component VII: Pain	0.936	0.010
Component VIII: General Health	0.027	-0.513
Component IX: Health Change	0.954	0.007
ODI Score	0.856	-0.022

Table 6. The Relationship Between Extremity Weakness and Post-Therapy ODI Scores

Variable	Weakness		*P**
	Yes	*No*	
Component I: Physical Functioning	80 (20-100)	85 (20-100)	0.929
Component II: Role Limitations Due to Physical Health	75 (50-100)	75 (50-100)	0.845
Component III: Role Limitations Due to Emotional Problems	100 (33-100)	100 (33-100)	0.931
Component IV: Energy/Fatigue	90 (60-100)	90 (55-100)	0.499
Component V: Emotional Well-Being	92 (80-100)	90 (60-100)	0.673
Component VI: Social Functioning	88 (63-100)	88 (50-100)	0.803
Component VII: Pain	88 (58-100)	78 (43-100)	0.374
Component VIII: General Health	85 (55-100)	80 (40-100)	0.798
Component IX: Health Change	75 (0-100)	75 (25-100)	0.376
ODI Score	4 (1-18)	4 (1-24)	0.625

* Mann-Whitney Test

Table 7. The Relationship Between Pain and Post-Therapy ODI Scores

Variable	Pain				*P**
	Without pain	*mild*	*moderate*	*severe*	
Component I: Physical Functioning	85 (20-95)	83 (30-95)	85 (20-100)	83 (20-100)	0.928
Component II: Role Limitations Due to Physical Health	75 (50-100)	75 (50-100)	75 (50-100)	75 (50-75)	0.705
Component III: Role Limitations Due to Emotional Problems	67 (33-100)	100 (67-100)	100 (33-100)	100 (67-100)	0.153
Component IV: Energy/Fatigue	90 (55-100)	90 (70-100)	90 (60-100)	88 (60-100)	0.980
Component V: Emotional Well-Being	88 (60-100)	90 (88-100)	92 (80-100)	90 (80-96)	0.702
Component VI: Social Functioning	88 (50-100)	88 (75-100)	88 (63-100)	81 (63-100)	0.815
Component VII: Pain	89 (43-100)	83 (55-100)	78 (55-100)	78 (58-100)	0.825
Component VIII: General Health	80 (40-100)	83 (55-100)	85 (55-95)	778 (55-100)	0.848
Component IX: Health Change	75 (25-100)	75 (0-100)	75 (0-100)	75 (50-100)	0.943
ODI Score	4 (1-24)	4 (3-14)	4 (1-18)	3 (2-13)	0.694

*Kruskal-Wallis Test

Table 8. The Relationship Between Type of Intervention and Post-Therapy ODI Scores

Variable	Intervention						P*
	Chemotherapy	Radiotherapy	Chemotherapy & Radiotherapy	Chemotherapy & Surgery	Radiotherapy & Surgery	All combination	
Componen I: Physical Functioning	90 (20-95)	90 (20-100)	70 (20-100)	75 (70-95)	40 (30-85)	90 (30-95)	0.065
Component II: Role Limitations Due to Physical Health	75 (50-100)	75 (50-100)	62,5 (50-100)	75 (50-100)	100 (50-100)	75 (50-100)	0.241

Table 8. Continued

Component III: Role Limitations Due to Emotional Problems	66.7 (33.3-100)	100 (66.7-100)	100 (33.3-100)	66.7 (33.3-66.7)	100(100-100)	66,7 (33,3-100)	0.067
Component IV: Energy/Fatigue	93 (60-100)	90(60-100)	85 (55.5-100)	85 (85-100)	90 (70-90)	90 (70-95)	0.716
Componen V: Emotional Well-Being	96 (80-100)	92 (84-96)	88 (60-100)	92 (84-96)	88 (88-92)	92 (80-96)	0.747
Componen VI: Social Functioning	93.8 (62.5-100)	100 62.5-100)	87.5 (50-100)	75 (75-100)	87.5(7.5-100)	87,5(75-100)	0.550
Component VII: Pain	90 (55-100)	90 (67.5-100)	77.5 (42.5-100)	90 (87.5-100)	77.5 (57.5-77.5)	87,5(57,5-100)	0.217
Componen VIII: General Health	95 (55-100)	90 (55-95)	72.5 (40-100)	90 (70-95)	60 (55-65)	90 (55-95)	0.145
Component IX: Health Change	75 (50-100)	75 (0-100)	75 (25-100)	50 (25-75)	50 (50-75)	75 (0-100)	0.306
Score ODI	4 (1-13)	3 (1-4)	5 (1-24)	9 (1-10)	8 (8-15)	4 (1-18)	0.054

*Kruskall Wallis Test

The Relationship Between Pre-Therapy and Post-Therapy SF-36 Scores and ODI Scores

In this study, significant differences were found in the pre-therapy and post-therapy SF-36 scores in Component I: Physical Functioning, Component II: Role Limitations Due to Physical Health, Component IV: Energy/Fatigue, Component VII: Pain, Component VIII: General Health, and ODI scores with a P-value of <0.05. Additionally, in patients undergoing surgery, the analysis of SF-36 scores showed significant differences in Component II: Role Limitations Due to Physical Health and ODI scores (P<0.05), which improved post-intervention. In patients with complaints of weakness or paralysis, interventions led to significant improvement in Component II: Role Limitations Due to Physical Health, Component IV: Energy/Fatigue, Component VIII: General Health, and ODI scores (P<0.05) [Tables 9-11].

Table 9. Pre-Therapy and Post-Therapy SF-36 Scores and ODI Scores

Variable	Median (Min-Max)		P*
	Score SF-36 Pretherapy	*Score SF-36 Posttherapy*	
Component I: Physical Functioning	85 (5-100)	85 (20-100)	0.026
Component II: Role Limitations Due to Physical Health	75 (0-100)	75 (50-100)	<0.001
Component III: Role Limitations Due to Emotional Problem	66.7 (0-100)	100 (33.3-100)	0.417
Component IV: Energy/Fatigue	90 (55-100)	90 (55-100)	0.001
Component V: Emotional Well-Being	92 (60-100)	92 (60-100)	0.722
Component VI: Social Functioning	87.5 (50-100)	87.5 (50-100)	0.726
Component VII: Pain	83.8 (12.5-100)	77.5 (42.5-100)	0.042
Component VIII: General Health	80 (40-100)	80 (40-100)	<0.001
Component IX: Health Change	75 (0-100)	75 (0-100)	0.147
Score ODI	8 (3-33)	4 (1-24)	<0.001

Table 10. Pre-Therapy and Post-Therapy SF-36 Scores and ODI Scores in Patients Undergoing Surgery

Variable	Median (Min-Max)		P*
	Score SF-36 Pretherapy	*Score SF-36 Posttherapy*	
Component I: Physical Functioning	85 (25-95)	85 (30-95)	0.123
Component II: Role Limitations Due to Physical Health	75 (25-100)	75 (50-100)	0.046
Component III: Role Limitations Due to Emotional Problem	66.7 (33.3-100)	66.7 (33.3-100)	0.581
Component IV: Energy/Fatigue	90 (55-100)	90 (70-100)	0.313
Component V: Emotional Well-Being	88 (72-96)	92 (80-96)	0.080
Component VI: Social Functioning	87.5 (62.5-100)	87.5 (75-100)	0.705
Component VII: Pain	87.5 (32.5-100)	87.5 (57.5-100)	0.232
Component VIII: General Health	80 (45-100)	85 (55-95)	0.072
Component IX: Health Change	75 (0-100)	75 (0-100)	0.566
ODI Score	11 (3-33)	6 (1-18)	0.002

Table 11. Pre-Therapy and Post-Therapy SF-36 Scores and ODI Scores in Patients with Complaints of Weakness or Paralysis

Variable	Median (Min-Max)		P*
	Score SF-36 Pretherapy	*Score SF-36 Posttherapy*	
Component I: Physical Functioning	85 (5-95)	80 (20-100)	0.108
Component II: Role Limitations Due to Physical Health	75 (0-100)	75 (50-100)	0.006
Component III: Role Limitations Due to EmotionalProblemsm	66,7 (0-100)	100 (33,3-100)	0.237
Component IV: Energy/Fatigue	90 (55-100)	90 (60-100)	0.011
Component V: Emotional Well-Being	92 (72-100)	92 (80-100)	0.139
Component VI: Social Functioning	87.5 (57.5-100)	87.5 (62.5-100)	0.549
Component VII: Pain	87.5 (12.5-100)	87.5 (57.5-100)	0.058
Component VIII: General Health	80 (45-100)	85 (55-100)	0.004
Component IX: Health Change	75 (0-100)	75 (0-100)	0.301
ODI Score	8 (3-33)	4 (1-18)	<0.001

*Wilcoxon Test

Discussion

A significant relationship between gender and SF-36 pain and general health components was found in this study, with females showing lower scores than males in both domains. One potential factor is the differences in pain perception and tolerance between genders. What is thought to cause this are hormones, such as oestrogen, that can modulate pain pathways and influence pain thresholds in women, as well as social and psychological factors related to gender roles, social expectations, and treatment mechanisms, which can cause differences in functional quality outcomes in women.[1,2]

In this study, age was found to correlate negatively with physical functioning, energy/fatigue, and general health components in the SF-36. Advanced age is associated with poorer functional outcomes, as reflected in SF-36 scores, due to several factors, including declining physical health and higher expectations for improvement in age-related weakness and frailty, which can affect perceptions of health-related quality of life. Advanced age is also associated with a higher prevalence of comorbidities. Additionally, elderly patients often experience a higher incidence of age-related conditions such as sarcopenia and osteoporosis, all of which can contribute to lowering SF-36 scores.[3-9]

In this study, no significant relationship was found between pain complaints and SF-36 scores. This finding contradicts results from several studies, including those by Parker et al., Kinney et al., Fontana et al., Elnady et al., and Aşkın et al., which all report that pain (chronic, severe, and/or neuropathic) is associated with lower SF-36 scores. One possible explanation is that our study did not include preoperative details on pain severity and neurological deficits, which are known to strongly influence postoperative outcomes. Another reason could be the subjectivity of pain reporting and the relatively small sample size in each subgroup, which may have limited the statistical power to detect differences.[10-16]

In this study, no significant relationship was found between the type of therapy and SF-36 scores. Common treatment options, such as surgery and radiotherapy, are insufficient to control disease spread without adjuvant therapy. Other management options include chemotherapy, targeted therapy, and evolving immunotherapy, which can target remaining tumour cells and can prevent recurrence, particularly in bone metastasis. The effects of chemotherapy and radiotherapy on physical quality of life and function in patients are later evaluated using the Functional Assessment of Cancer Therapy-General (FACT-G) questionnaire. Talbot et al. concluded that surgery did not improve the quality of life of patients with bone metastasis, nor did it change the physical or mental aspects of it. However, surgery did change the pain scale. Additional research shows that the quality of life and survival of patients with bone metastasis fractures are influenced by chemotherapy and radiotherapy, where they can increase patient life expectancy from 4.1 months to 14.2 months. A study by Nascimento et al. suggests that radiotherapy and surgery are palliative interventions. Palliative radiotherapy generally becomes an effective option when a patient with spinal metastasis cannot undergo surgery. This study also indicates that operative procedures are highly effective in reducing pain and improving quality of life. Research by Shih et al. suggests that surgical intervention for bone metastasis can increase healing rates in patients with bone metastasis, thereby improving quality of life, while also considering controlling primary tumours and overall health.[9,17-24]

There was no significant correlation between genders and ODI scores in this study. This contradicts other studies that found that males had lower ODI scores in adult spinal deformity but higher scores in metastatic bone disease. These findings are due to several factors, such as the fact that males were more commonly found having progressive metastatic bone disease, had a higher pain scale, and lower functional capacity compared to females. Additionally, males were found to have higher expectations after receiving surgery, which could contribute to higher ODI scores.[25-29]

In this study, no significant relationship between age and ODI scores was found. This finding is consistent with other studies, as the different settings across studies further support the conclusion that age plays no significant role in determining ODI scores. This happens because, in the elderly, physical condition is lower and they are more prone to illness than younger people. Older people tend to have comorbidities, such as osteoporosis, which can make compression fractures more frequent. Older age is also related to the spreading of the secondary malignant spine tumor. For example, Smith et al. conducted a prospective, multicenter study involving 479 patients aged 60 years and older who underwent spinal deformity surgery and found significant improvements in ODI scores across all age groups. At 2 years, nearly 70% of patients demonstrated a 20% or greater improvement in ODI, indicating that advanced age did not preclude functional recovery.[30-43]

In this study, no significant relationship was found between pain and ODI scores. This is thought to be caused by the subjectivity of pain perception. Additionally, ODI cannot comprehensively capture the complexity of pain. Other questionnaires, such as PROMIS, are more favourable in this case. In addition, psychosocial factors affect ODI scores. Similar findings were reported by Parker et al., who analyzed over 1,000 patients with chronic low back pain and found that pain intensity scores correlated only moderately with ODI outcomes. This result suggests that disability perception extends beyond pain alone.[30,44-47]

In this study, there was no significant relationship between extremity weakness complaints and ODI scores. ODI itself cannot comprehensively assess extremity weakness, so it is considered insufficiently sensitive. Another questionnaire, named SOSGOQ, may be a more reliable choice for assessing the effects of extremity weakness complaints in patients with spinal tumours. This finding aligns with Versteeg et al., who showed that motor deficits had only a limited influence on ODI scores in patients undergoing surgery for lumbar spinal stenosis, reinforcing the notion that ODI underestimates the impact of extremity weakness. Furthermore, Fehlings et al. demonstrated that the SOSGOQ was more responsive than the ODI in detecting functional limitations associated with neurological deficits in patients with spinal oncology, making it a preferable tool in this population.[48-50]

In this study, five SF-36 components showed significant changes before and after therapy: physical functioning, role limitations due to physical health, fatigue, pain, and general health. Radiotherapy is mentioned in previous studies as one of the chosen treatments when surgical intervention is not feasible. Research by Zeng et al. demonstrates that SBRT therapy can improve overall quality of life in patients with spinal bone metastasis. Regarding surgical management, this study shows a significant difference between Component II: Role Limitations Due to Physical Health scores and ODI scores before and after surgery. This aligns with prior research by Quan et al., Kumar et al., and Molina et al., which all state that surgery is a method for pain management, enhancing spinal stability, improving neurological deficits, and improving patient survival and function, thereby effectively enhancing patient quality of life. Regarding SF-36 scores, Chen et al. noted that surgery can significantly improve quality of life, both mentally and physically.[17,18,51-61]

This study identified open decompression and posterior stabilization as the most common types of spinal surgery, performed in 10 patients (58.82%), and vertebroplasty in 4 patients (23.53%). The combination of open decompression and posterior stabilization procedures in patients with metastatic spinal bone disease has shown significant benefits in improving neurological deficit symptoms, pain management, and better spinal stability. Minimal-invasive techniques for decompression and stabilization also yield positive functional outcomes, including minimal morbidity compared to conventional open surgery, which aligns with findings from Yang et al. and Shakil et al., who reported comparable neurological and functional improvements following decompression and stabilization procedures in metastatic spine disease. Vertebroplasty, a common minimally invasive procedure for managing spinal fractures, has shown positive effects in patients with spinal bone metastasis, effectively reducing pain, improving mobility, restoring vertebral body height, and enhancing function. Furthermore, vertebroplasty has been associated with low complication rates and favourable functional and oncological outcomes.[62-67]

This study indicates the significant impact of change between pre- and post-procedural ODI scores. These findings align with previous research by Viswanathan et al., Dowling and Lewandrowski, and Qi et al., which indicate that ODI scores can significantly increase in patients undergoing surgery for lower back pain, including those with spinal bone metastasis.[59,60,68,69]

This study shows significant differences in SF-36 scores for component II: Role Limitations due to Physical Health, component IV: Energy/Fatigue, component VIII: General Health, and pre-therapy and post-therapy ODI scores in patients with weakness or paralysis. These can happen due to weakness and neurological deficit in patients.[70-74]

The results of this study are consistent with previous research by Qiao et al., which found that therapies such as surgery, bisphosphonates, and chemotherapy can support bone survival, thereby improving patients' functional quality and quality of life. Research by Choi et al shows similar results. This is illustrated by improvements in ODI and VAS scores in patients.[75,76] Spinal metastatic bone disease represents one of the most debilitating conditions encountered in orthopedic oncology, leading to pain, neurological impairment, and significant reductions in patients' quality of life. Its management continues to evolve alongside advances in surgical reconstruction, targeted therapy, and palliative care approaches. Recent publications have enriched the understanding of musculoskeletal oncology and postoperative functional outcomes, particularly regarding reconstructive strategies and precision medicine in bone tumors. Jamshidi et al. reported favorable outcomes of megaprosthesis reconstruction following failed osteoarticular allografts around the knee in young patients with primary bone sarcoma, highlighting the long-term functional recovery achievable through modern reconstructive approaches.[77] Furthermore, their bibliometric analysis on osteosarcoma management underscored the transition toward individualized treatment protocols that integrate molecular insights and functional outcomes as core therapeutic goals.[78] These perspectives complement current investigations into spinal metastatic disease, emphasizing the need to evaluate not only survival and radiographic success but also the overall quality of life and functional independence of patients.[79]

This study has several limitations. One limitation is the risk of recall bias, especially among patients with long-standing symptoms, as recalling past complaints may affect the accuracy and validity of the collected data. In this study, data collection was conducted by telephone, which may have led to a less comprehensive assessment of patient complaints and functional outcomes than direct patient examinations. The retrospective design of this study also has inherent limitations, including incomplete data and a lack of control over confounding factors. In addition, the follow-up period was relatively short, which may not fully reflect patients' long-term outcomes.

Other limitations include analyzing patient age only as a continuous variable without subgrouping, and failing to analyze the relationship between primary tumor types and outcomes, even though tumor type can markedly affect prognosis. The indications for different surgery options were not recorded, and there was an unequal distribution of subjects across procedure types, which may reduce the statistical power of groups with fewer subjects. Finally, all parameters used in this study, including pain, SF-36, and ODI, were self-assessed and self-administered, which may introduce subjectivity in the results.

Conclusion

In the study, significant connections emerged among various factors impacting patient outcomes. Female gender was linked to a reduction in post-therapy SF-36 pain and general health scores. Younger age groups showed notable enhancements in post-therapy physical functioning, energy levels, and general health scores. Additionally, the analysis revealed substantial associations between pre- and post-therapy SF-36 and ODI scores. Similarly, pre- and post-surgery assessments showed significant improvements in SF-36 scores related to physical health limitations, as well as enhanced post-surgery ODI scores, indicating positive shifts in patient health and quality of life following surgical interventions.

Further research could enhance the study by increasing the sample size and focusing on specific categories. Future research may involve multisite studies to increase sample size, use the Spine Oncology Study Group (SOSG) scoring system for a more holistic patient assessment, and employ both prospective and retrospective cohort study designs to evaluate outcomes such as survival rates.

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References

1. Wallenhammar LM, Nyfjäll M, Lindberg M, Meding B. Health-Related Quality of Life and Hand Eczema—A Comparison of Two Instruments, Including Factor Analysis. J Invest Dermatol.2004; 122(6):1381-1389 doi:10.1111/j.0022-202x.2004.22604.x.
2. Core MA Del, Ahn J, Wukich DK, et al. Gender Differences on SF-36 Patient-Reported Outcomes of Diabetic Foot Disease. Int J Low Extrem Wounds. 2018;17(2):87-93 doi:10.1177/1534734618774664.
3. Lim JBT, Yeo W, Chen JLT. Preoperative Leg Pain Score Predicts Patient Satisfaction After Transforaminal Lumbar Interbody Fusion Surgery. Global Spine J. 2018;8(4):354-358. doi:10.1177/2192568217723888.
4. Kim HKW, Almakias R, Millis MB, Vakulenko-Lagun B. How Are Adults Who Had Perthes' Disease Functioning? Bone Joint J. 2022;104-B(12):1304-1312. doi: 10.1302/0301-620X.104B12.BJJ-2022-0764.R1.
5. Harris JE, MacDermid JC, Roth JH. The International Classification of Functioning as an Explanatory Model of Health After Distal Radius Fracture: A Cohort Study. Health Qual Life Outcomes. 2005;3(1):73. doi:10.1186/1477-7525-3-73.
6. Holterhues C, Cornish D, Poll-Franse LV van de, et al. Impact of Melanoma on Patients' Lives Among 562 Survivors. Arch

Dermatol. 2011;147(2):177-85. doi:10.1001/archdermatol.2010.433.
7. Sadjadi R, Rose MR, Tawil R, et al. What Determines Quality of Life in Inclusion Body Myositis? J Neurol Neurosurg Psychiatry. 2010;81(10):1164-6. doi:10.1136/jnnp.2009.183863.
8. Randell A, Nguyen T V, Bhalerao N, Silverman SL, Sambrook PN, Eisman JA. Deterioration in Quality of Life Following Hip Fracture: A Prospective Study. Osteoporosis International. 2000;11(5):460-6. doi:10.1007/s001980070115.
9. Talbot M, Turcotte R, Isler M, Normandin D, Iannuzzi D, Downer P. Function and Health Status in Surgically Treated Bone Metastases. Clin Orthop Relat Res. 2005;438:215-20. doi:10.1097/01.blo.0000170721.07088.2e.
10. Ghogawala Z, Resnick DK, Watters WC, et al. Guideline Update for the Performance of Fusion Procedures for Degenerative Disease of the Lumbar Spine. Part 2: Assessment of Functional Outcome Following Lumbar Fusion. J Neurosurg Spine. 2014;21(1):7-13. doi:10.3171/2014.4.spine14258.
11. Hilton M, Gioe TJ, Noorbaloochi S, Singh JA. Increasing Comorbidity Is Associated With Worsening Physical Function and Pain After Primary Total Knee Arthroplasty. BMC Musculoskelet Disord. 2016;17(1):421. doi:10.1186/s12891-016-1261-y.
12. Kinney MAO, Hooten WM, Cassivi SD, et al. Chronic Postthoracotomy Pain and Health-Related Quality of Life. Ann Thorac Surg. 2012;93(4):1242-7.doi:10.1016/j.athoracsur.2012.01.031.
13. Dubinsky MC, Armuzzi A, Gecse K, et al. Improvements in Disease Activity Partially Mediate the Effect of Tofacitinib Treatment on Generic and Disease-Specific Health-Related Quality of Life in Patients With Ulcerative Colitis: Data From the OCTAVE Program. Dig Dis. 2023;41(4):604-614. doi:10.1159/000528788.
14. Parker SL, Mendenhall SK, Shau DN, et al. Determination of Minimum Clinically Important Difference in Pain, Disability, and Quality of Life After Extension of Fusion for Adjacent-Segment Disease. J Neurosurg Spine. 2012 ;16(1):61-7.doi:10.3171/2011.8.spine1194.
15. Fontana RJ, Moyer CA, Sonnad SS, et al. Comorbidities and Quality of Life in Patients With Interferon-Refractory Chronic Hepatitis C. Am J Gastroenterol. 2001 ;96(1):170-8. doi:10.1111/j.1572-0241.2001.03473.x.
16. Elnady B, Taha AA, Desouky DES, et al. Impact of Sustained Remission on Quality of Life Among Women With Rheumatoid Arthritis and Systemic Lupus Erythematosus: A Prospective Observational Study. Egyptian Rheumatology and Rehabilitation. 2021; 48(1):23. doi:10.1186/s43166-021-00072-3.
17. Fomchenko EI, Bayley JC, Alvarez-Breckenridge C, Rhines LD, Tatsui CE. Spinal Metastases and the Evolving Role of Molecular Targeted Therapy, Chemotherapy, and Immunotherapy. Neurospine. 2022;19(4):978-993. doi:10.14245/ns.2244290.145.
18. Atanasio JMP, Neumann CS, Nerlich M. The Regensburg Protocol for Spinal Metastases. Coluna/Columna. 2013;12:334-336. doi:10.1590/s1808-18512013000400016.
19. Raoof AM, Yacoub S, Asaad YA, Hadithi TS Al. Quality of Life Among Cancer Patients Treated With Chemotherapy or Radiotherapy in Erbil City an Evaluation Study. Cancer Clin Oncol. 2015;4(1):19-27. doi:10.5539/cco.v4n1p19.
20. Salim X, D'Alessandro P, Little J V, et al. A Novel Scoring System to Guide Prognosis in Patients With Pathological Fractures. J Orthop Surg Res. 2018;13(1):228.doi:10.1186/s13018-018-0931-x.
21. Nascimento O, Pereira G do AV, Morais MJ de D, Feitosa A do NA, Campos MF de, Rodrigues LMR. Surgery Associated With Radiotherapy in Patients Affected by Metastatic Medular Compression: Scientific Production of the Health Area. Journal of Human Growth and Development. 2021; 31(2):318-335. doi:10.36311/jhgd.v31.12226.
22. Kim JM, Losina E, Bono CM, et al. Clinical Outcome of Metastatic Spinal Cord Compression Treated With Surgical Excision ± Radiation Versus Radiation Therapy Alone. Spine (Phila Pa 1976). 2012;37(1):78-84. doi:10.1097/brs.0b013e318223b9b6.
23. Shih JT, Yeh TT, Wang C, Wang S, Chien WC, Chung C. Effects of Surgical Intervention for Bone Metastases on Survival in Patients With Advanced Cancer: A Nationwide Population-Based Cohort Study. Int J Gen Med. 2021 May 3;14:1661-1671. doi:10.2147/ijgm.s307547.
24. Ju DG. Diagnosis and surgical management of breast cancer metastatic to the spine. World J Clin Oncol. 2014;5(3):263-71. doi:10.5306/wjco.v5.i3.263.
25. Prevost CLD, Azahaf M, Nachury M, et al. Bowel Damage and Disability in Crohn's Disease: A Prospective Study in a Tertiary Referral Centre of the Lémann Index and Inflammatory Bowel Disease Disability Index. Aliment Pharmacol Ther. 2020;51(9):889-898. doi:10.1111/apt.15681.
26. Kuo YK, Lin Y, Lee C, et al. Novel Insights Into the Pathogenesis of Spinal Sarcopenia and Related Therapeutic Approaches: A Narrative Review. Int J Mol Sci. 2020;21(8):3010. doi:10.3390/ijms21083010.
27. Bahouq H, Allali F, Hanan R, Hmamouchi I, Hajjaj–Hassouni N. Profile of Sexuality in Moroccan Chronic Low Back Pain Patients. BMC Musculoskelet Disord. 2013;14:63. doi:10.1186/1471-2474-14-63.
28. Bima C, Bioletto F, Lopez C, et al. Clinical and Pathological Tools for Predicting Recurrence and/or Metastasis in Patients With Pheochromocytoma and Paraganglioma. Biomedicines. 2022;10(8):1813. doi:10.3390/biomedicines10081813.
29. Swarup I, Henn CM, Gulotta L V, Henn RF. Patient Expectations and Satisfaction in Orthopaedic Surgery: A Review of the Literature. J Clin Orthop Trauma. 2019;10(4):755-760. doi:10.1016/j.jcot.2018.08.008.
30. Fairbank J, Pynsent P. The Oswestry Disability Index. Spine (Phila Pa 1976). 2000;25(22):2940-52. doi:10.1097/00007632-200011150-00017.
31. Sîrbu E, Onofrei RR, Szasz S, Susan M. Predictors of Disability in Patients With Chronic Low Back Pain. Archives of Medical Science. 2020;19(1):94-100. doi:10.5114/aoms.2020.97057.
32. Barker K, Shamley D, Jackson DA. Changes in the Cross-Sectional Area of Multifidus and Psoas in Patients With Unilateral Back Pain. Spine (Phila Pa 1976). 2004;29(22):E515-9. doi:10.1097/01.brs.0000144405.11661.eb.
33. Kircelli A, Çöven İ. Percutaneous Balloon Kyphoplasty Vertebral Augmentation for Compression Fracture Due to

Vertebral Metastasis: A 12-Month Retrospective Clinical Study in 72 Patients. Medical Science Monitor. 2018;24:2142-2148. doi:10.12659/msm.909169.

34. Zaina F, Tomkins-Lane C, Carragee EJ, Négrini S. Surgical Versus Nonsurgical Treatment for Lumbar Spinal Stenosis. Spine (Phila Pa 1976). 2016;41(14):E857-E868. doi:10.1097/brs.0000000000001635.
35. Verma S, Pal BP. Correlation Between Pain, Fear of Falling and Disability in Low Back Pain. Ann Rehabil Med. 2015;39(5):816-20. doi:10.5535/arm.2015.39.5.816.
36. Davergne T, Bailly F, Foltz V, Lambert A, Fautrel B, Gossec L. Effectiveness of a Short Functional Restoration Program for Patients With Chronic Low Back Pain: A Cohort Study of 193 Patients. Joint Bone Spine. 2020;87(6):640-646. doi:10.1016/j.jbspin.2020.05.011.
37. Akazawa T, Kotani T, Sakuma T, et al. Impact of the COVID-19 Pandemic on Middle-Aged and Older Patients With Adolescent Idiopathic Scoliosis Who Underwent Spinal Fusion: A Questionnaire-Based Survey. Cureus. 2023;15(1):e34370. doi:10.7759/cureus.34370.
38. Wagner SC, Sebastian AS, McKenzie JC, et al. Severe Lumbar Disability Is Associated With Decreased Psoas Cross-Sectional Area in Degenerative Spondylolisthesis. Global Spine J. 2018;8(7):716-721. doi:10.1177/2192568218765399.
39. Nascimento TC, da Silva PA, Gonçalves LC, dos Santos AP, Passos XS, Silva AM, Carneiro LC, Neto EA. Comparison between surgical procedures and conservative treatments to reduce disability caused by low back pain-systematic review and meta-analysis. Brazilian Journal of Development. 2021;7(4):40964-74.doi:10.34117/bjdv7n4-520.
40. Al-Bedri K, Ali RM, Mahmood ZA. Relationship Between Disability and Radiographic Findings of Lumbar Disk Degeneration in Sample of Iraqi Patients With Mechanical Low Backache. Asian Journal of Pharmaceutical and Clinical Research. 2021;14(2):83-88. doi:10.22159/ajpcr.2021.v14i2.40166.
41. Li K, Gong H, Xie R, et al. Clinical Efficacy of Zoledronic Acid Combined With Percutaneous Kyphoplasty in the Prevention and Treatment of Osteoporotic Vertebral Compression Fracture. Medicine. 2021;100(13):e25215. doi:10.1097/md.0000000000025215.
42. Discrimination of metastatic from acute osteoporotic compression spinal fractures with MR imaging. Radiographics. 2003;23(1):179-87. doi:10.1148/rg.231025043.
43. Pan W, Ruan B. Surgical Decompression via the Unilateral Intervertebral Foraminal Approach With Local Anesthesia for Treating Elderly Patients With Lumbar Central Canal Stenosis. Neurosurg Focus. 2021;51(6):E5. doi:10.3171/2021.9.focus21420.
44. Qiu Y, Zhang K, Ye X, et al. Combination of Microwave Ablation and Percutaneous Osteoplasty for Treatment of Painful Extraspinal Bone Metastasis. Vasc Interv Radiol. 2019;30(12):1934-1940. doi:10.1016/j.jvir.2019.08.008
45. Smith H, Gee L, Kumar V, et al. Deep Brain Stimulation Significantly Decreases Disability From Low Back Pain in Patients With Advanced Parkinson's Disease. Stereotact Funct Neurosurg. 2015;93(3):206-11. doi:10.1159/000380827.
46. Bijker L, Wit L de, Cuijpers P, Poolman EY, Scholten-Peeters GGM, Coppieters MW. Back2Action: Effectiveness of Physiotherapy Blended With eHealth Consisting of Pain Education and Behavioural Activation Versus Physiotherapy Alone—protocol for a Pragmatic Randomised Clinical Trial for People With Subacute or Persistent Spinal Pain. BMJ Open. 2022;12(1):e050808. doi:10.1136/bmjopen-2021-050808.
47. Camino-Willhuber G, Schönnagel L, Caffard T, et al. Severe Intervertebral Vacuum Phenomenon Is Associated With Higher Preoperative Low Back Pain, ODI, and Indication for Fusion in Patients With Degenerative Lumbar Spondylolisthesis. Clinical Spine Surgery a Spine Publication. 2023;37(1):E1-E8. doi:10.1097/bsd.0000000000001510.
48. Gao N, Qiao Z, Yan S, Zhu L. Evaluation of Health-Related Quality of Life and Influencing Factors in Patients With Crohn Disease. Journal of International Medical Research. 2022;50(5):3000605221098868. doi:10.1177/03000605221098868.
49. Bhatt S, Boody B, Savage JW, Hsu WK, Rothrock N, Patel AA. Validation of Patient-Reported Outcomes Measurement Information System Computer Adaptive Tests in Lumbar Disk Herniation Surgery. J Am Acad Orthop Surg. 2019 ;27(3):95-103. doi:10.5435/jaaos-d-17-00300.
50. Paulino Pereira NR, Janssen SJ, Raskin KA, et al. Most efficient questionnaires to measure quality of life, physical function, and pain in patients with metastatic spine disease: a cross-sectional prospective survey study. Spine J. 2017;17(7):953-961. doi:https://doi.org/10.1016/j.spinee.2017.02.006.
51. Zeng K, Tseng C, Soliman H, Weiss Y, Sahgal A, Myrehaug S. Stereotactic Body Radiotherapy (SBRT) for Oligometastatic Spine Metastases: An Overview. Front Oncol. 2019;9:337. doi:10.3389/fonc.2019.00337.
52. Ferini G, Palmisciano P, Scalia G, et al. The Role of Radiation Therapy in the Treatment of Spine Metastases From Hepatocellular Carcinoma: A Systematic Review and Meta-Analysis. Neurosurg Focus. 2022;53(5):E12. doi:10.3171/2022.8.focus2255.
53. Malik Z, Fenwick JD. Radiotherapy to the Primary Tumour for Patients With Metastatic Prostate Cancer: Practice-Changing Results From STAMPEDE. Clin Oncol. 2020;32(5):327-329. doi:10.1016/j.clon.2019.12.010.
54. Malik YG, Benth JŠ, Hamre HM, Færden AE, Ignjatovic D, Schultz JK. Chemotherapy reduces long-term quality of life in recurrence-free colon cancer survivors (LaTE study)-a nationwide inverse probability of treatment-weighted registry-based cohort study and survey. Colorectal Dis. 2023;26(1):22-33. doi:10.1111/codi.16807.
55. Quan GMY, Vital JM, Aurouer N, et al. Surgery Improves Pain, Function and Quality of Life in Patients With Spinal Metastases: A Prospective Study on 118 Patients. Eur Spine J. 2011;20(11):1970-8. doi:10.1007/s00586-011-1867-6
56. Kumar N, Ravikumar N, Tan JYH, Akbary K, Patel R, Kannan R. Current Status of the Use of Salvaged Blood in Metastatic Spine Tumour Surgery. Neurospine. 2018;15(3):206-215. doi:10.14245/ns.1836140.070.
57. Molina CA, Gokaslan ZL, Sciubba DM. A Systematic Review of the Current Role of Minimally Invasive Spine Surgery in the Management of Metastatic Spine Disease. Int J Surg Oncol. 2011; 2011(1): 598148. doi:10.1155/2011/598148.
58. Slover J, Abdu WA, Hanscom B, Weinstein JN. The Impact of Comorbidities on the Change in Short-Form 36 and Oswestry

Scores Following Lumbar Spine Surgery. Spine (Phila Pa 1976). 2006;31(17):1974-80. doi:10.1097/01.brs.0000229252.30903.b9.

59. Viswanathan VK, Kukreja S, Minnema AJ, Farhadi HF. Prospective Assessment of the Safety and Early Outcomes of Sublaminar Band Placement for the Prevention of Proximal Junctional Kyphosis. J Neurosurg Spine. 2018;28(5):520-531. doi:10.3171/2017.8.spine17672.
60. Dowling Á, Lewandrowski KU. Endoscopic Transforaminal Lumbar Interbody Fusion With a Single Oblique PEEK Cage and Posterior Supplemental Fixation. Int J Spine Surg. 2020;14(s3):S45-S55. doi:10.14444/7126.
61. Qi L, Li M, Si H, et al. The Clinical Application of "Jetting Suture" Technique in Annular Repair Under Microendoscopic Discectomy. Medicine. 2016;95(31):e4503. doi:10.1097/md.0000000000004503.
62. Ziu M, Traylor JI, Paxman J, Goodgame BW. Stereotactic Vertebroplasty for Spinal Metastases with Multilevel Bilateral Pedicle Fractures: A Technical Note. Cureus. 2019;11(2):e4123. doi:10.7759/cureus.4123.
63. Berton A, Salvatore G, Giambini H, et al. A 3D finite element model of prophylactic vertebroplasty in the metastatic spine: Vertebral stability and stress distribution on adjacent vertebrae. J Spinal Cord Med. 2020;43(1):39-45. doi:10.1080/10790268.2018.1432309.
64. Stangenberg M, Viezens L, Eicker SO, Mohme M, Mende KC, Dreimann M. Cervical vertebroplasty for osteolytic metastases as a minimally invasive therapeutic option in oncological surgery: Outcome in 14 cases. Neurosurg Focus. 2017;43(2):E3. doi:10.3171/2017.5.FOCUS17175.
65. Luo J, Bertram W, Sangar D, Adams MA, Annesley-Williams DJ, Dolan P. Is kyphoplasty better than vertebroplasty in restoring normal mechanical function to an injured spine? Bone. 2010;46(4):1050-1057. doi:10.1016/j.bone.2009.11.036.
66. Cardarelli-Leite L, Rassekh SR, D'Ortenzio R, Heran MKS. Vertebroplasty as a palliative treatment option for intractable pain in pediatric patients with spinal tumors. Pediatr Blood Cancer. 2021;68(12):e29307. doi:10.1002/pbc.29307.
67. Farrokhi MR, Derakhshan N, Rezaei H, Shamspour SZ. Standalone Transoral Vertebroplasty for Treatment of Painful Metastatic C2 Lesion: A Case Report. Arch Neurosci. 2019;6(3):e86148. doi:10.5812/ans.86148.
68. Khan MB, Bashir MU, Kumar R, Enam SA. Enduring Improvement in Oswestry Disability Index Outcomes Following Lumbar Microscopic Interlaminar Decompression: An Appraisal of Prospectively Collected Patient Outcomes. J Craniovertebr Junction Spine. 2015;6(4):195-9. doi:10.4103/0974-8237.167881.
69. Langella F, Ventriglia L, Compagnone D, et al. The Influence of Baseline Clinical Status and Surgical Strategy on Early Good to Excellent Result in Spinal Lumbar Arthrodesis: A Machine Learning Approach. J Pers Med. 2021;11(12):1377. doi: 10.3390/jpm11121377.
70. Lyulin S, Balaev P, Subramanyam KN, Ivliev D, Mundargi AV. Three-Dimensional Endoscopy-Assisted Excision and Reconstruction for Metastatic Disease of the Dorsal and Lumbar Spine: Early Results. Clin Orthop Surg. 2022;14(1):148-154. doi:10.4055/cios21006.
71. Buijs GS, de Gendt EEA, Sadiqi S, Post MW, Muijs SPJ, Oner FC. Long-Term Reliability and Validity of the AO Spine PROST (Patient-Reported Outcome Spine Trauma).Spine (Phila Pa 1976). 2022;47(17):E562-E569.
72. Liu S, Zhou X, Song A, Huo Z, Wang Y, Liu Y. Surgical treatment of metastatic mesenchymal chondrosarcoma to the spine: A case report. Medicine. 2020;99(5):e18643. doi: 10.1097/MD.0000000000018643.
73. Al Farii H, Frazer A, Farahdel L, Alfayez S, Weber M. Zoledronic Acid Versus Denosumab for Prevention of Spinal Cord Compression in Advanced Cancers With Spine Metastasis: A Meta-Analysis of Randomized Controlled Trials. Global Spine J. 2019;10(6):784-789. doi:10.1177/2192568219884069.
74. Guzik G. Oncological and functional results of the surgical treatment of vertebral metastases in patients with multiple myeloma". BMC Surg. 2017;17(1):92. doi:10.1186/s12893-017-0288-9.
75. Qiao R, Zhang HR, Ma RX, Li R, Yang X. Prognostic Factors for Bone Survival and Functional Outcomes in Patients With Breast Cancer Spine Metastases. Technol Cancer Res Treat. 2022; 21:15330338221122642. doi:10.1177/15330338221122642.
76. Choi J, Lee SY, Hwangbo G. Influences of Spinal Decompression Therapy and General Traction Therapy on the Pain, Disability, and Straight Leg Raising of Patients With Intervertebral Disc Herniation. J Phys Ther Sci. 2015;27(2):481-3. doi:10.1589/jpts.27.481.
77. Jamshidi K, Ammar W, Kargar Shooroki K, Mirzaei A. Outcomes of Megaprosthesis Reconstruction for the Salvage of Failed Osteoarticular Allograft Around the Knee implanted before Skeletal Maturity in Primary Bone Sarcoma: A Case-Series. Arch Bone Jt Surg. 2024;12(3):211-218. doi:10.22038/abjs.2023.74212.3434.
78. Jamshidi K, Hajialiloo Sami S, Naghizadeh H, Kargar Shooroki K, Ahmadi R, Khabiri SS. Osteosarcoma Management in the Precision Medicine Era: Bibliometric Analysis and Clinical Progress (2015–2024). Arch Bone Jt Surg. 2025;13(11):693-703. doi:10.22038/abjs.2025.87193.3953.
79. Sadek WS, Ahmed AG, Abou Senna WG, Ebeid WA. Does Unplanned Excision of Soft Tissue Sarcomas Affect the Oncological Outcome: A retrospective study. Arch Bone Jt Surg. 2025. Article in press. doi:10.22038/abjs.2025.87788.3973.