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Osteosarcoma of the Spine: A Comprehensive Review with Two Case Illustrations

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ABSTRACT

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Background: Osteosarcoma of the spine is an uncommon but aggressive primary malignant bone tumor, comprising less than 5% of all osteosarcomas.[1,3] Its anatomical constraints and proximity to the spinal cord make diagnosis and treatment particularly challenging.[1,2]

Objective: To review the epidemiology, pathology, clinical features, diagnostic modalities, treatment options, and prognosis of spinal osteosarcoma, supplemented by two illustrative clinical cases.

Methods: Narrative review synthesizing current literature and surgical oncology principles, supported by two representative clinical cases treated by the senior author.

Results: Multimodal therapy, including surgery, chemotherapy, and radiotherapy, remains essential for optimal outcomes.[7-9] En bloc resection provides superior local control but is often limited by spinal anatomy[6]. The cases demonstrate the contrasting clinical courses: one long-term survivor and one typical aggressive outcome.

Conclusion: Early diagnosis, multidisciplinary management, and advanced surgical techniques[9,13] offer better prognosis in these aggressive malignancies . Continued innovations may enhance future survival also.

Keywords: Spinal Osteosarcoma, Spinal Tumors, En Bloc Spondylectomy, Chemotherapy, Radiotherapy, Spine Oncology.

*See End Note for complete author details

INTRODUCTION

Osteosarcoma is the most common primary malignant bone tumor.[4] However, spinal involvement is rare and represents a diagnostic and therapeutic challenge. Accounting for less than 5% of all osteosarcomas.[1,3,11] Spinal osteosarcoma differs from appendicular disease due to its variable age of onset, high rates of neurological compromise(1.5), and difficulty achieving adequate surgical margins.[6,9] The present review examines key aspects of spinal osteosarcoma and presents two illustrative cases.

AETIOLOGY

The etiology of osteosarcoma includes both primary and secondary causes. Primary osteosarcoma arises de novo, whereas secondary osteosarcoma may develop following radiation therapy, Paget's disease, or chronic bone disorders.[4] Genetic predispositions include TP53 mutations (Li-Fraumeni syndrome), RB1 mutations[4] (hereditary retinoblastoma), and RECQL4 mutations[4] (Rothmund- Thomson syndrome). Despite these associations, most cases arise sporadically.

PATHOLOGY

Spinal osteosarcoma exhibits malignant spindle cells producing osteoid, with osteoblastic, chondroblastic, and fibroblastic histological subtypes.[4] High-grade variants predominate and often demonstrate cortical destruction, soft tissue mass formation, and epidural spread.[1] The degree of tumor necrosis after neoadjuvant chemotherapy is a predictor of prognosis.[7,11]

CLINICAL PRESENTATION

Patients commonly present with back pain, often nocturnal and unrelieved by rest.[5] Neurological

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deficits occur due to epidural invasion or vertebral collapse, manifesting as radiculopathy, myelopathy, weakness, or sphincter dysfunction.[5,12] Spinal deformity or pathological fractures may occur. Systemic symptoms such as fever or weight loss are uncommon unless metastases are present.[3]

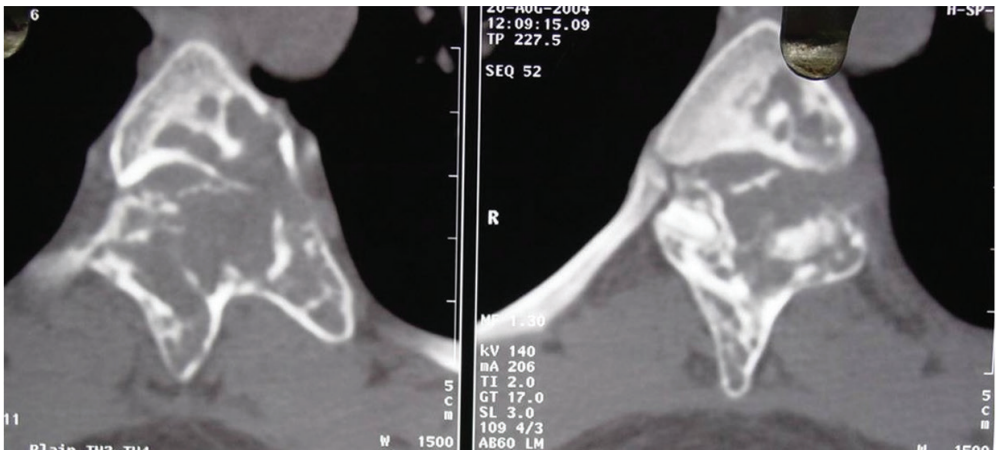

Figure 1: Case 1 imaging photographs (CT pictures)

DIAGNOSTIC METHODS

MRI is the gold standard for evaluating marrow replacement, soft tissue extension, and neural compression.[5] CT scan provides superior assessment of cortical destruction and mineralized osteoid.[2] PET-CT assists with staging and detection of metastatic disease.[3] A CT-guided core needle biopsy is mandatory for definitive diagnosis and should be planned along future surgical corridors.[5,6]

TREATMENT METHODS

Multimodal therapy is the cornerstone of management. En bloc spondylectomy with wide surgical margins offers the best chance for local control,[6] although this may not always be feasible. Intralesional decompression may be necessary for neurological preservation. Chemotherapy typically includes high-dose methotrexate, cisplatin, ifosfamide,[7] and doxorubicin. Radiotherapy is reserved for unresectable tumors[11] or residual disease, with advanced modalities such as proton and carbon-ion therapy showing improved local control.[1,9,13]

CASE 1: LONG-TERM SURVIVOR OF EXTRA-COMPARTMENTAL SPINAL OSTEOSARCOMA

A 15-year-old girl presented with back pain after a fall. MRI showed destruction of the D4 vertebral body with epidural extension compressing the spinal cord **(Figures 1 & 2).** She underwent angioembolisation followed by emergency posterior decompression and stabilization. Biopsy confirmed high-grade osteosarcoma **(Figures 3 & 4).**

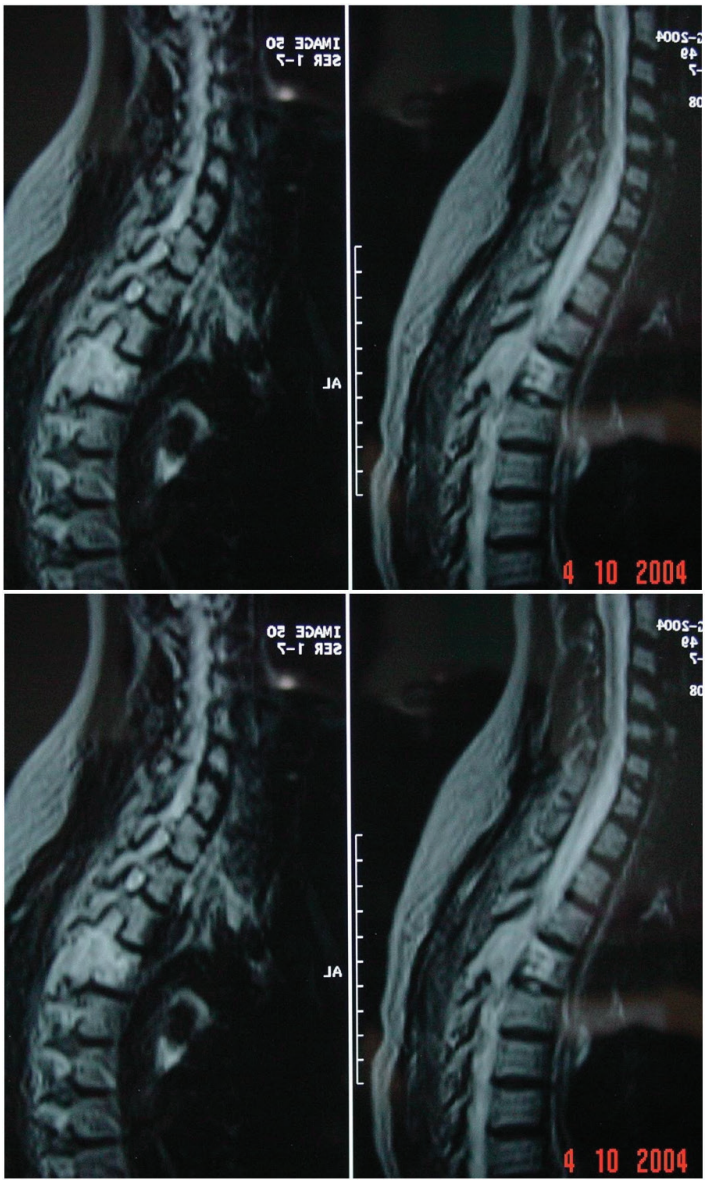

Figure 2: Case 1 imaging photographs (MRI pictures)

One week later, she underwent trans-axillary D4 corpectomy, tricortical iliac crest strut grafting, and anterior fixation **(Figures 5, 6 & 7).** She received chemotherapy and radiotherapy. Now, 21 years later, she remains disease-free, neurologically intact, married, and a mother-a rare example of long-term survival.

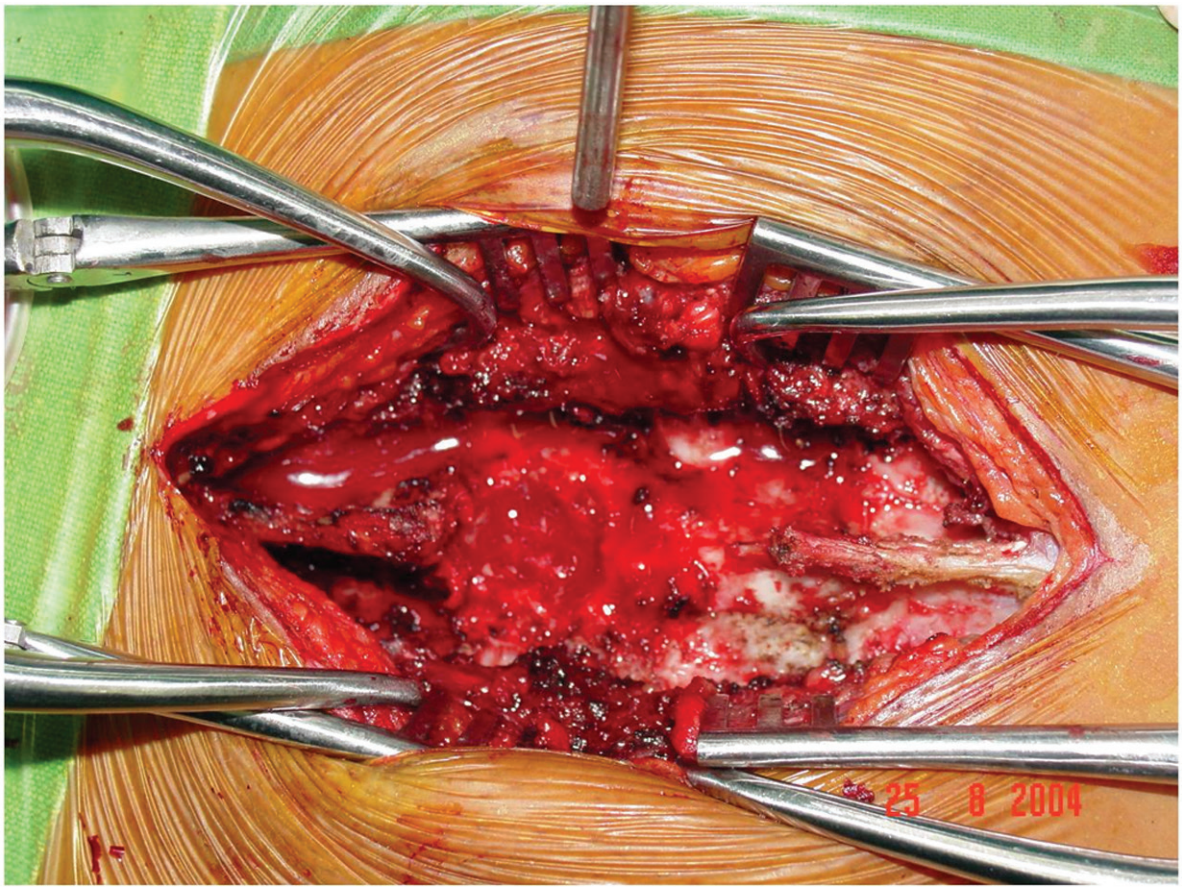

Figure 3: Case 1 intraoperative photographs.

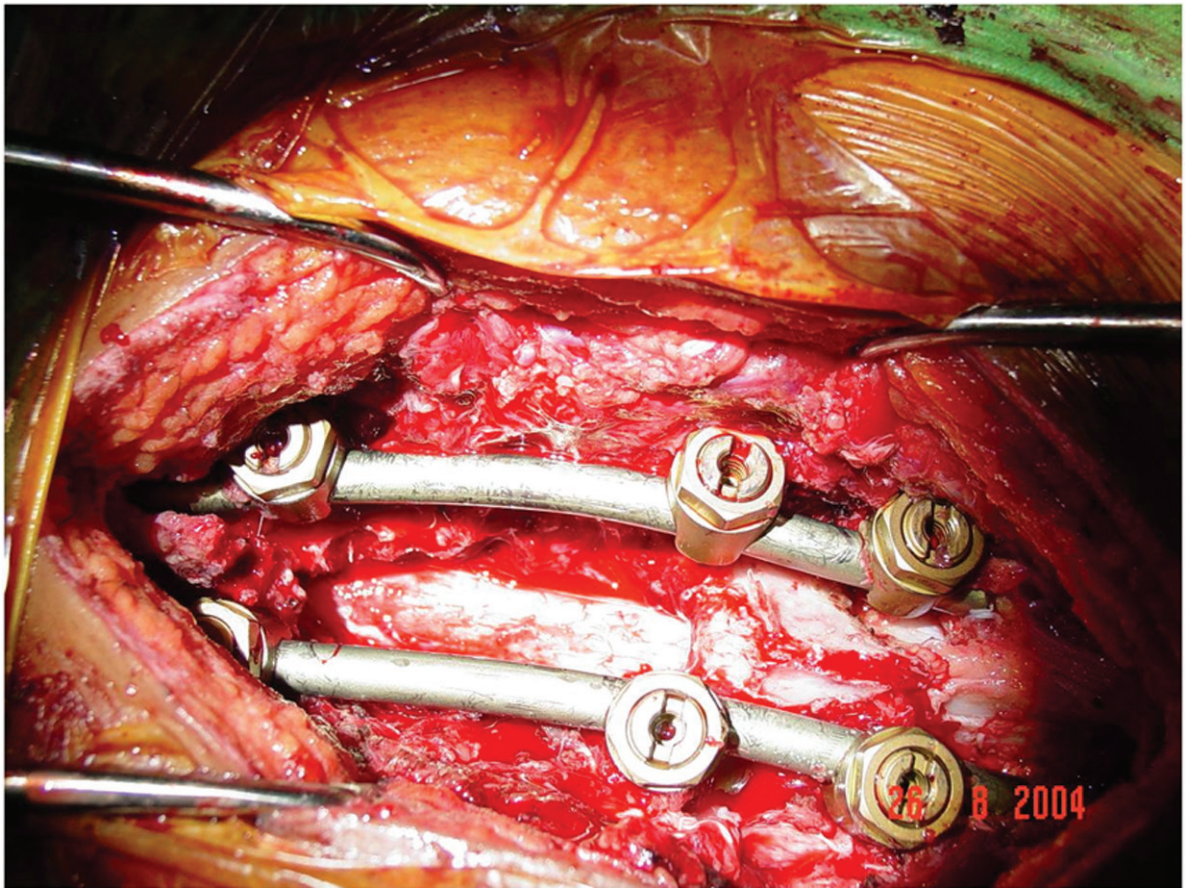

Figure 4: Case 1 intraoperative photographs.

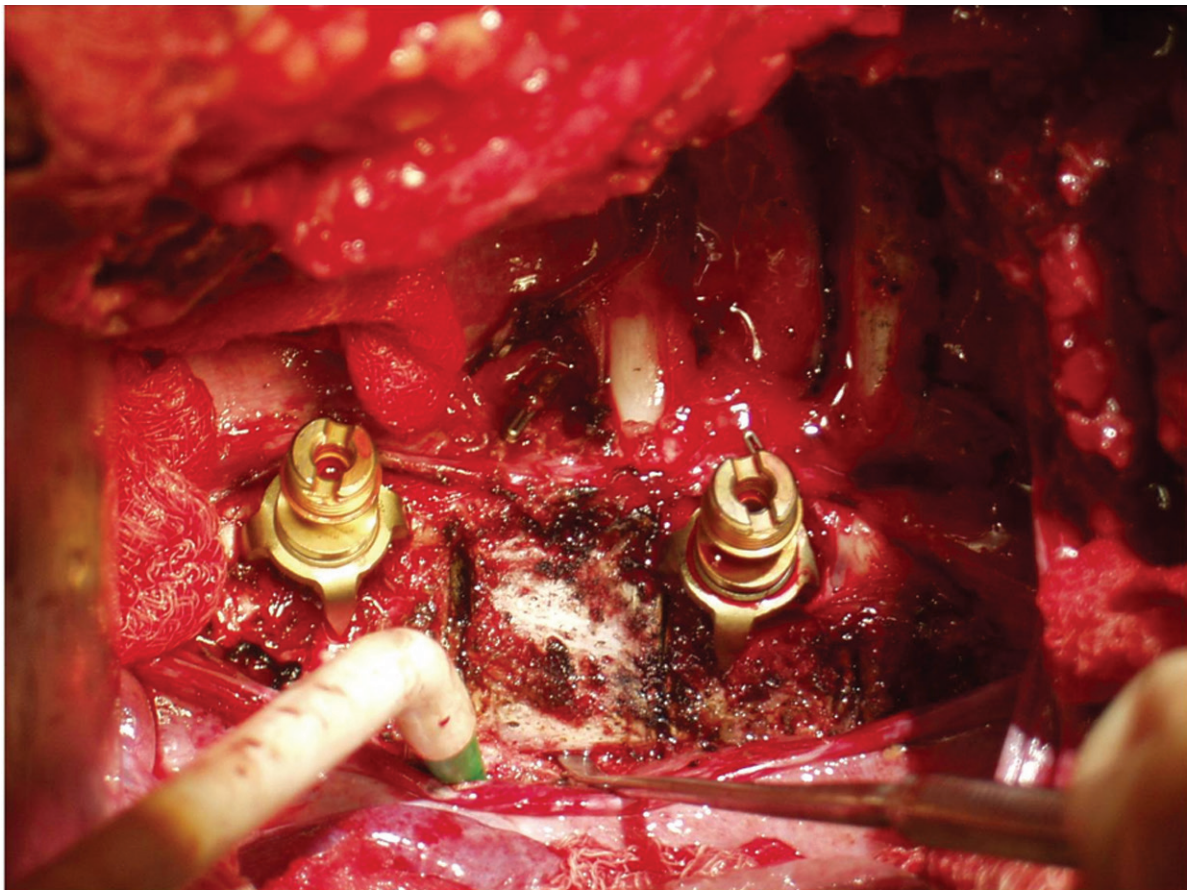

Figure 5: Case 1 intraoperative photographs.

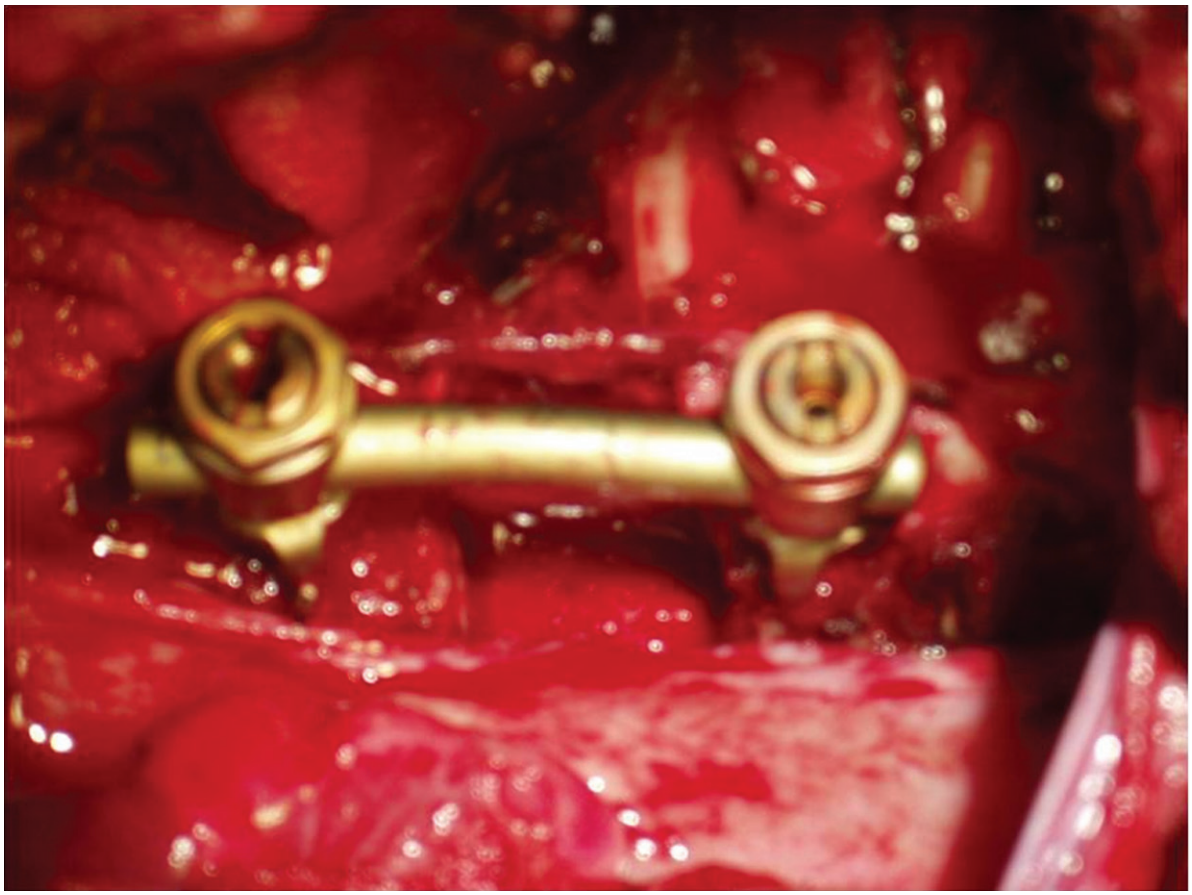

Figure 6: Case 1 intraoperative photographs.

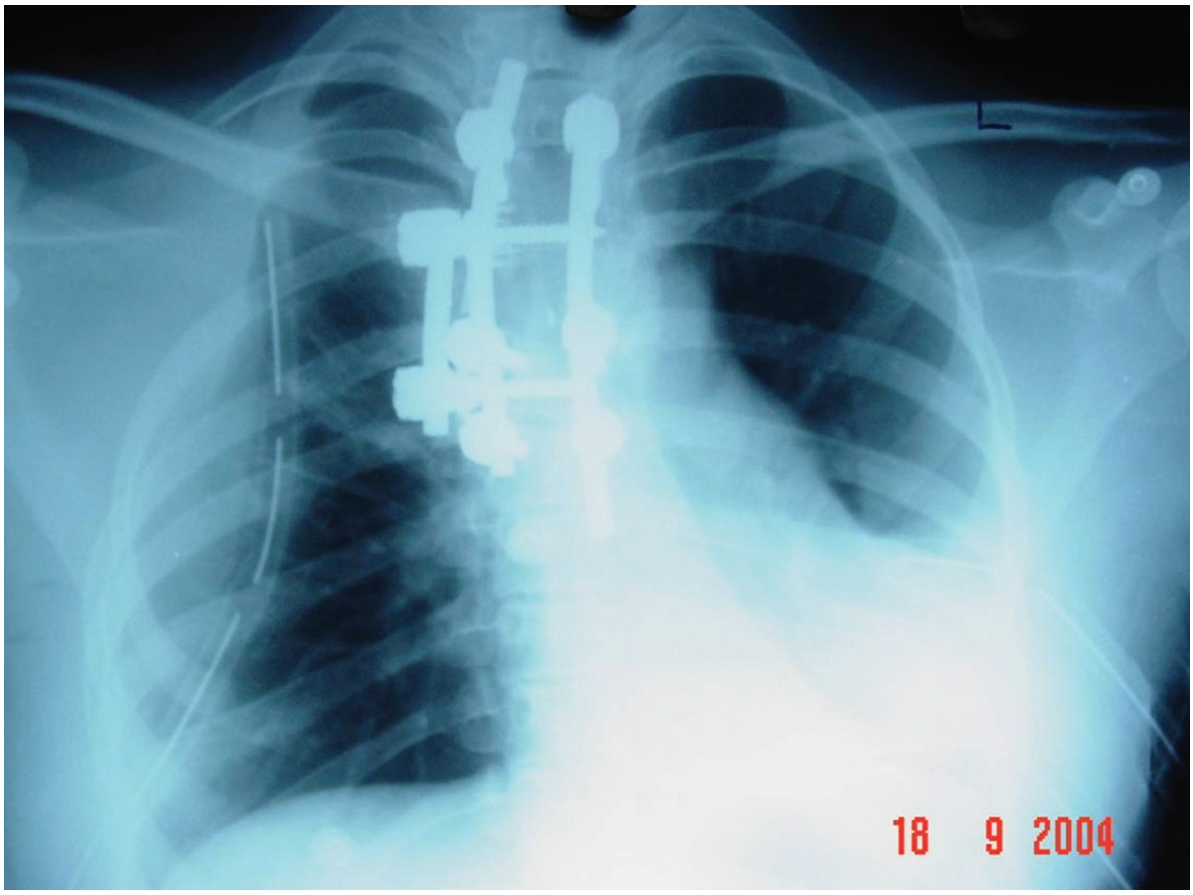

Figure 7: Case 1 post operative X-Rays

CASE 2: RIB AND VERTEBRAL OSTEOSARCOMA

A 22-year-old male presented with upper thoracic pain radiating to the anterior chest **(Figures 8,9,10,11 and 12)**. Radiographs revealed a dense rib lesion. MRI demonstrated tumor involving the rib and adjacent vertebra. After angioembolisation, a combined transthoracic and posterior approach was used for tumor excision with pedicle screw fixation **(Figure 13)**. He received adjuvant chemotherapy and radiotherapy but survived only two years, reflecting the typical aggressive behavior of axial osteosarcoma.

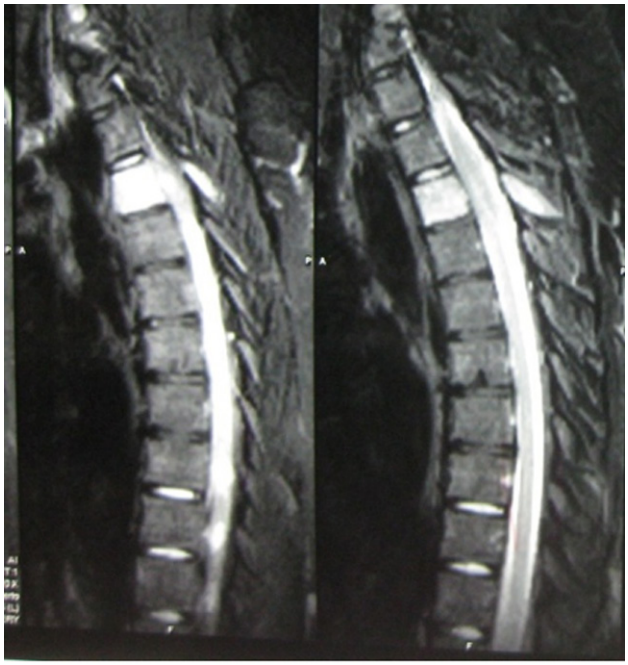

Figure 8: Case 2 MRI showing vertebral involvement

Complications

Complications arise from both tumor progression and treatment. Disease-related complications include pathological fractures, spinal instability, cord compression, and pulmonary metastases.[1,3,5] Treatment-related complications include wound infection, graft or implant failure, chemotherapy toxicity, and radiation-induced injury[7,8] to the spinal cord or surrounding structures.

Prognosis

Prognosis depends on tumor grade, adequacy of surgical margins, and response to chemotherapy.[1,7,11] Five-year survival ranges between 30-50%, lower than appendicular osteosarcoma.[1,12] Long-term survival is uncommon,[11,13] though Case 1 demonstrates that aggressive multimodal therapy can achieve excellent results.[6,9]

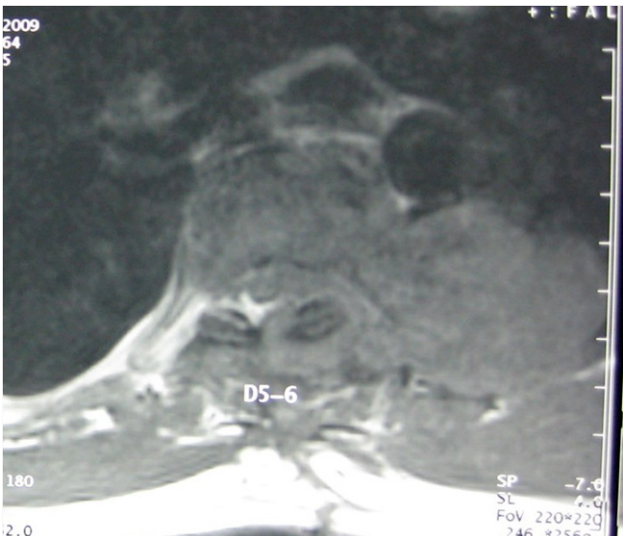

Figure 9: Case 2 imaging photographs.

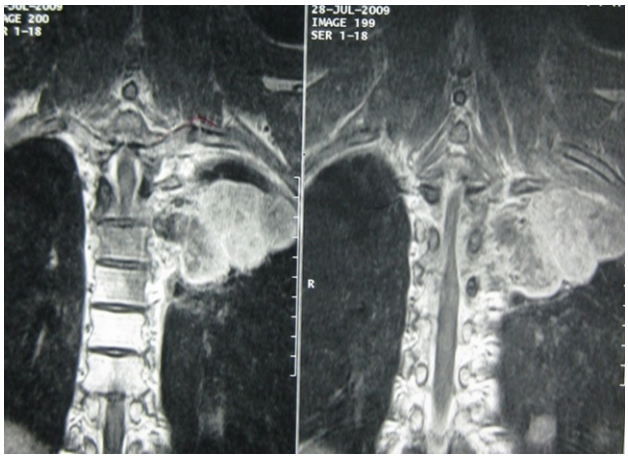

Figure 10: Case 2 coronal section showing tumor out growth into thoracic cavity and cord compression

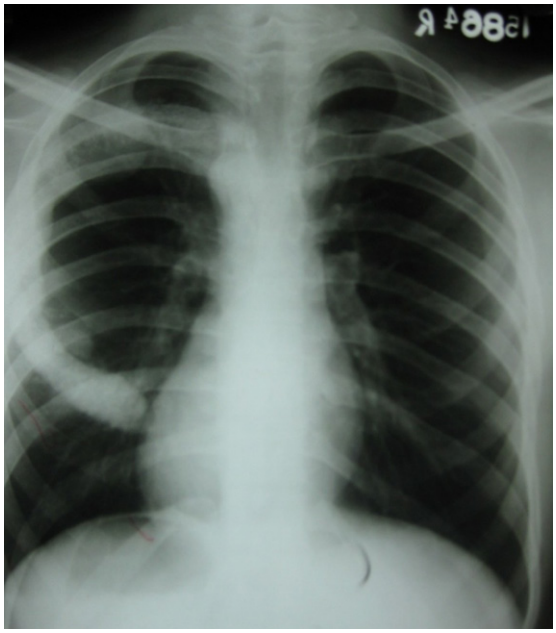

Figure 11: Case 2 X-Ray Chest showing involved sclerotic rib.

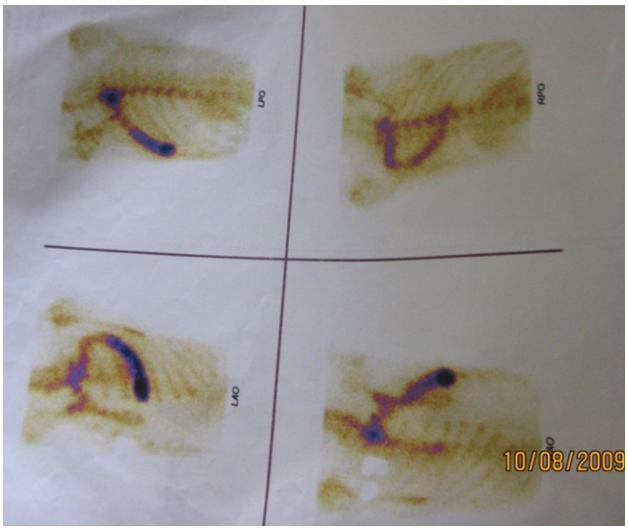

Figure 12: Case 2 bone scan shows the involvement.

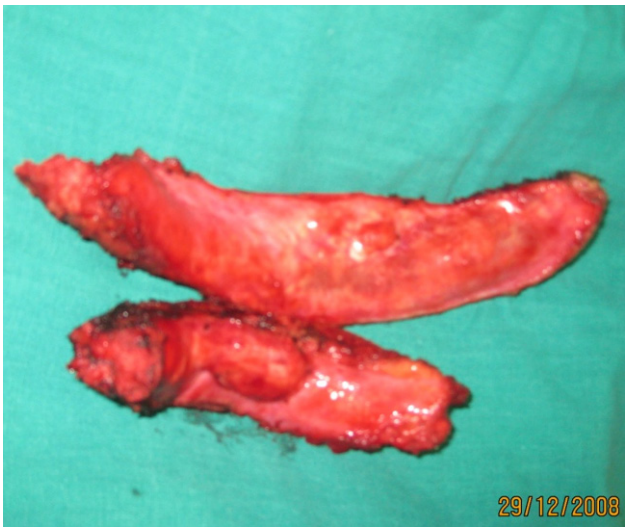

Figure 13: Case 2 resected rib during surgery

Newer Treatment Modalities

Novel treatments include carbon-ion radiotherapy, which provides superior dosimetry and biological effectiveness.[8] Targeted therapies such as VEGF inhibitors, IGF-1R blockers, and mTOR inhibitors are under investigation.[3] Immunotherapies, including checkpoint inhibitors and CAR-T cell approaches, show early promise but require further study.[10]

Future Prospects

Future developments are likely to include precision oncology, enhanced surgical planning through robotics and navigation, and 3D-printed implants for spinal reconstruction.[9] Artificial intelligence may support improved diagnostic accuracy and individualized prognostication.[10,13]

Take-home Message

Spinal osteosarcoma is an aggressive malignancy requiring early diagnosis, multimodal treatment, and coordinated multidisciplinary care. Although prognosis remains guarded, long-term survival is achievable in selected patients.[9,13] Continued advances in imaging, surgical techniques, radiotherapy, and biologically targeted therapies hold promise for improving outcomes.

END NOTE

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Conflict of Interest: None declared

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