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CASE REPORT Open Access

Utility of C arm aided, CT guided, and O arm navigation aids to surgically manage cases of spinal osteoblastoma over a decade

Shailesh Ramakant Hadgaonkar, Siddharth Manik Katkade*, Pramod Dashrath Bhilare and Parag Kantilal Sancheti

Abstract

Background Spinal osteoblastoma needs surgical intervention, and over a decade with advancing technologies, different radiological aids have been utilized in the form of CT scan, fluoroscopy and O arm, but no study has compared its efficacy and outcomes. Here, in this case report of three cases, we have compared the intra- and post-operative course and effectiveness of three radiological modalities.

Case presentation We reviewed three surgically treated cases of spinal osteoblastoma with aid of different generation radiological modalities like C arm, CT scan and O arm navigation treated over a span of more than 10 years in single institute by same surgeon. These 3 cases were assessed and compared in terms of intraoperative parameters (image acquisition type, image display, scan time, bone image quality, real-time imaging, radiation exposure, surgical time, blood loss, complications and others) and post-operative parameters (recovery, recurrence and follow-up). First case managed with aid of C arm showed fluoroscopically acquired two-dimensional images, poor bone image quality; higher scan time-surgical time and blood loss with higher radiation exposure and no real-time imaging. Second case managed with aid of CT scan provided three-dimensional images, better bone image quality; lower surgical time and blood loss but increased transport time with minimum radiological exposure to surgeon and OT personnel with no real-time imaging. Third case managed with O arm navigation provided 3-dimensional images, best bone image quality; less surgical time and blood loss with minimum radiological exposure to surgeon and OT personnel with real-time imaging. Additionally, O arm navigation improved accuracy of tumor localization and intraoperative confirmation of complete tumor excision. Whereas all three cases showed no clinico-radiological signs of recurrence on subsequent follow-ups.

Conclusion O arm navigation in terms of best bone image quality, accuracy, intraoperative confirmation of tumor excision, surgical time, blood loss and post-operative recovery makes it superior to others.

Keywords Osteoblastoma, C arm, CT scan, O arm navigation, Surgical excision, Case report

Introduction

Spinal osteoblastoma needs surgical intervention and over a decade with advancing technologies different radiological aids has been utilized in the form of CT scan, fluoroscopy and O arm but no study has compared its efficacy and outcomes. Here, in this case report of three cases, we have compared the intra- and post-operative course and effectiveness of three radiological modalities.

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Methods

We reviewed three surgically treated cases of spinal osteoblastoma with aid of different generation radiological modalities like C arm, CT scan and O arm navigation treated over a span of more than 10 years in single institute by same surgeon. These 3 cases were assessed and compared in terms of intraoperative parameters (image acquisition type, image display, scan time, bone image quality, real-time imaging, radiation exposure, surgical time, blood loss, complications and others) and postoperative parameters (recovery, recurrence and follow-up).

Case 1 A 27-year male presented with mid-back pain from 6 months of VAS 9/10 with list on left side and normal neurological examination. The thoracolumbar radiograph was consistent with thoracic scoliosis with sclerosis around the T10 pedicle with no obvious bony destruction. Hematological studies showed slightly raised alkaline phosphatase. MRI showed an extradural lesion in right T10–11 neural foramen with surrounding marrow edema (Fig. 1a). The CT scan showed a well-defined extraosseous lesion in the right T10–11 neural foramen with ossified rim and a central lytic component representing nidus (Fig. 1b). With posterior midline approach, 2D fluoroscopy (C arm) guided surgical excision of tumor (Fig. 1c) with right-sided laminectomy, facetectomy, and unilateral instrumented (Fig. 1e) fusion was planned, keeping osteoid osteoma as the most probable diagnosis. Sample sent for histopathological evaluation was suggestive of osteoblastoma. (Fig. 1d) Postoperatively, the patient was significantly relieved of pain VAS 2/10, and neurologic signs were intact. 5 years follow-up patient was asymptomatic with radiographs; CT scan showed no signs of recurrence and solid fusion (Fig. 1f).

Case 2 29 years male presented with pain and swelling over left upper back region since 9 months of VAS8/10 with occasional left upper limb radiating pain and night pain. On examination, there was diffuse tender fullness present over left paraspinal upper dorsal region with full spinal range of movement restored and normal neurological examination. Dorsal spine radiographs were inconclusive, but MRI showed a hypointense (on both T1WI and T2WI) lesion on left D2 transverse process. CT scan showed oval lytic lesion with central sclerotic foci on left D2 transverse process (Fig. 2a). Radiological reporting was suggestive of osteoid osteoma or osteoblastoma. Surgical excision of the lesion with CT aid was planned. Preoperative CT guided and intraoperative c arm guided localization of D2 level and lesion was done with the help

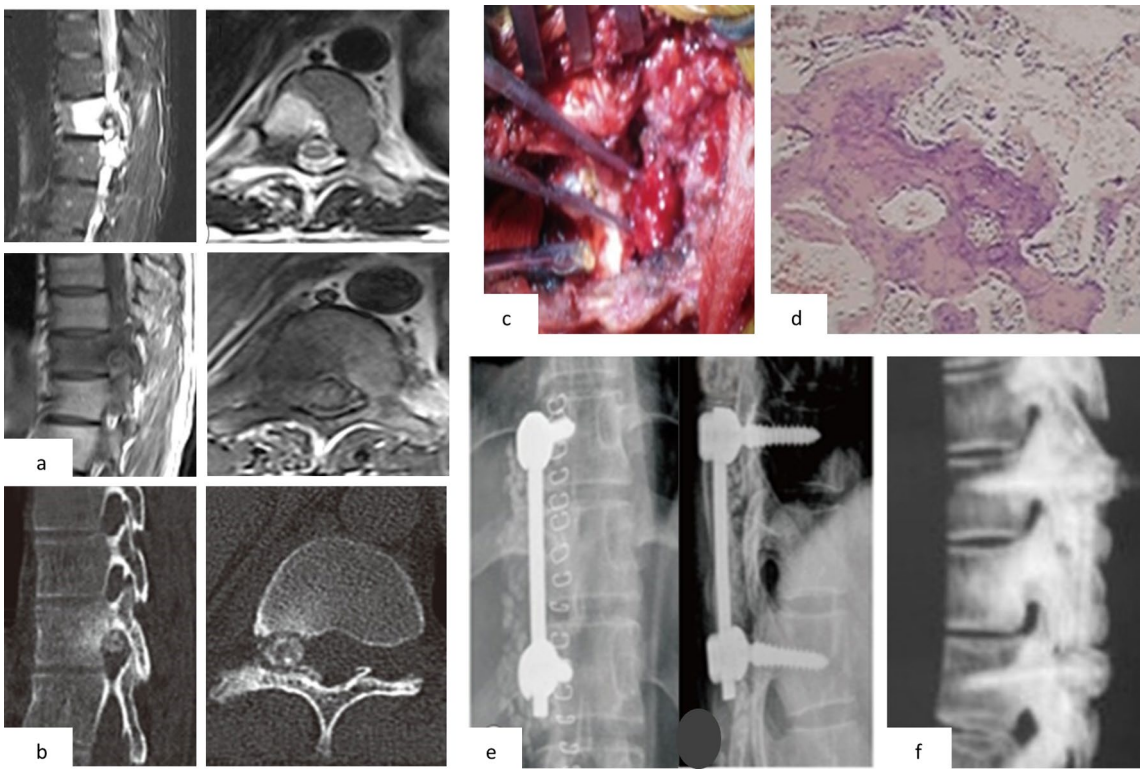

Fig. 1 *Case 1* **a** T1w and T2w MRI showing extraosseous foraminal lesion with vertebral body edema, **b** CT sagittal and axial section showing extraosseous lytic lesion with sclerotic rim in neural foramen, **c** excised tumor mass, **d** HPE slide confirming osteoblastoma, **e** Post-operative AP and lateral X-ray confirming implant positioning, **f** 5 years follow-up CT scan showing fusion

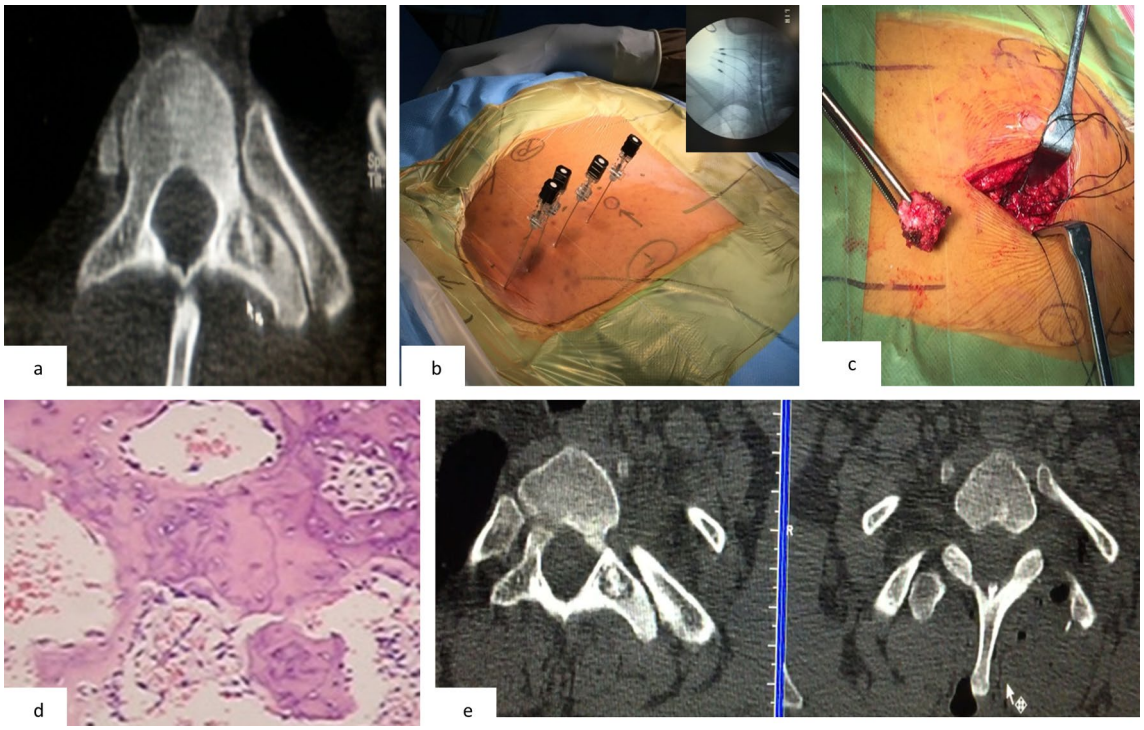

Fig. 2 *Case 2* **a** Axial CT showing D2 vertebral transverse process lytic and central sclerotic lesion, **b** preoperative CT followed by intraoperative C arm localization of D2 level, **c** excised tumor mass, **d** HPE slide confirming osteoblastoma, **e** pre- and post-operative comparative axial CT cut showing complete removal of tumor

of 16-gauge needle (Fig. 2b). Incision spanning D1 to D3 level was taken with unilateral left-sided exposure, with the help of in situ needle D2 transverse process was localized and excised along with lesion with burr drill and osteotome and also the needle was removed (Fig. 2d). In order to confirm the level of excision, patient under anesthesia was shifted to CT console and dorsal limited CT was performed which confirmed complete removal of D2 transverse process (Fig. 2e). The complete tissue mass was sent for histopathological evaluation which was conclusive for osteoblastoma (Fig. 2c). Patient improved symptomatically with reduction of VAS to 2/10. Three years follow-up patient was asymptomatic and showed no clinico-radiological signs of recurrence.

Case 3 A 29-year-old male presented with 8 months of mid-back pain and 2 months of the left-sided chest wall discomfort with VAS 8/10. His examination revealed diffuse mid-back tenderness but no neurological deficit. X-rays showed a mixed sclerotic/lytic lesion involving the left D12 pedicle. MRI showed an extradural left-sided D11–12 foraminal lesion involving left superior articular process and pedicle of D12 (Fig. 3a). CT scan showed; a floating foraminal radiolucent lesion, pedicular cortical ballooning, and breach with peridiscal osteophytes (Fig. 3b). These findings were consistent with the diagnosis of an osteoblastoma. O arm navigation aided complete excision of the tumor with unilateral instrumented fusion from D11 to L1 level was done (Fig. 3c, d). The patient was mobilized the next day, and gradually, his back pain improved to 3/10 on the VAS scale. The histopathological evaluation confirmed the diagnosis of an osteoblastoma (Fig. 3d). The latest 2-year postoperative follow-up revealed that the patient was asymptomatic without tumor recurrent on the CT scan (Fig. 3d).

Results

As stated in Table 1, use of 2D fluoroscopy (C arm) provides suboptimal quality and accuracy intraoperative images leading to increase dissection, blood loss and operative time, whereas use of pre- and intraoperative CT improves accuracy with good quality images but extends total anesthesia time due to intraoperative patient transport. At the same time, O arm navigation gives real time good quality images with higher accuracy and precision significantly decreasing surgical time, blood loss and radiation exposure to OT personnel with additional advantage of intraoperative CT scan.

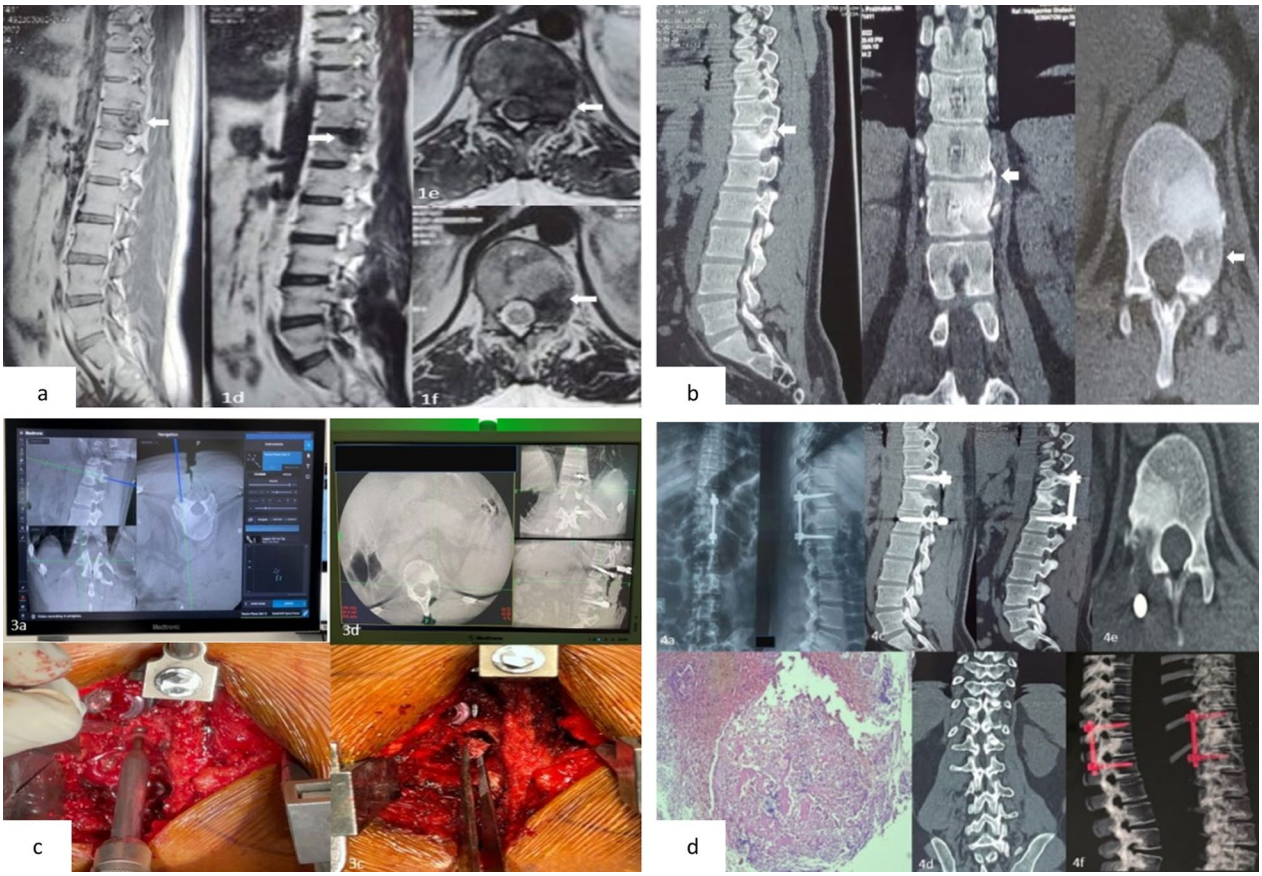

Fig. 3 *Case 3* **a** MRI images, sagittal and axial T1w and T2w cuts showing hypointense lesion surrounded by isointense shadow (white arrows); **b** CT images, sagittal image showing floating foraminal nidus, coronal image showing peridiscal osteophyte, axial image showing thinned out ballooned cortex (white arrows); **c** Intra-operative images; navigation guided exact location of nidus, burring superior articular process of D12 and inferior articular process of D11 and following the path and excision of nidus; **d** Postoperative X-ray and 2 years follow-up CT images showing loss of lytic and sclerotic shadow, absent nidus, no signs of recurrence and HPE image confirming Osteoblastoma

Table 1 Case-wise comparison of intraoperative radiological and surgical parameters

Image acquisition	Case 1: 2D fluoroscopy (C arm)	Case 2: pre- and intraoperative CT	Case 3: O arm navigation
Image display	2D (AP and Lateral)	3D	3D
Scan time	Multiple AP and lateral radiographic images	Intraoperative transport to CT console	30 s
Bone image quality	Poor	Good	Good
Real-time imaging	No	No	Yes
Surgical time (min)	180	250	120
Blood loss (ml)	500	300	150
Radiation exposure	Patient↓ OT Personnel↓	Patient↑↑ OT Personnel↓	Patient↑↑ OT Personnel↓
Clinical/radiological recurrence	No	No	No

Discussion

Osteoblastoma is an uncommon benign bone-forming neoplasm that accounts for about 1% of all primary bone tumors. It commonly arises in the posterior elements of the spine and the sacrum [1]. Some authors have reported equal frequency of these tumors in the cervical, thoracic, and lumbar spine [2]. Others have reported the cervical and lumbar spine to be the predominant spinal segments involved, followed by the thoracic region and sacrum [3]. Our all 3 cases had

thoracic-level involvement which is supposed to be the rare presentation.

Persistent pain, increasing tumor size, neurological deficits, and potential for malignant transformation and bony destruction due to aggressive behavior that may destroy neighboring spinal stability and neurovascular structures are the stated surgical indications for spinal osteoblastoma [4]. In all our 3 cases persistent pain and potential for malignant transformation were the surgical indications.

Due to inconspicuous nature of osteoid osteoma and osteoblastoma the radiological diagnosis is anecdotal. Nemoto et al. [5] have published the largest study on multimodal imaging approaches to diagnose osteoblastoma which included majorly CT and radiographs-based diagnosis. CT scan is known to accurately locate the lesion. Though MRI provides best soft tissue resolution, the role MRI in diagnosing osteoblastoma is controversial. Some authors recommend both MRI and CT scan in such cases and others claim MRI as misleading due to peritumoral inflammation mimicking malignant behavior [6]. Liu et al. in a study on 35 cases of MRI-based diagnosed osteoblastomas found out 87% detectability rate. Mainly T2W images adequately delineate the nidus and surrounded bone marrow edema in vertebral body with its inverse relation to distance of nidus. Also, soft tissue edema is seen extending to adjacent muscle bundle [6].

Literature states that radical resection of the osteoblastoma yields the best overall outcome. More favorable outcome is been documented from total excision of an osteoblastoma than subtotal excision (curettage) combined with radiation therapy. It has also been shown that total excision reduces relapse rates. A complete spondylectomy may be warranted in cases with extensive posterior element, pedicular and vertebral body involvement. Instrumented stabilization and fusion are warranted to ensure long-term stability and to prevent a progressive deformity in cases where substantial amount of the facet joint or pars interarticularis is removed. [7] Rajasekaran et al. [8] stated over advantages of CT navigation in precisely locating the tumor, minimizing bone removal in turn maintaining spinal integrity and minimizing the need of instrumented stabilization. Utilization of video-assisted thoracoscopic in combination with 3D navigation for excision of thoracic vertebral osteoid osteoma is been published by Campos et al. [9] where the real time thoracoscopic and navigation-based localization and on table confirmation of tumor resection is been highlighted.

Radiofrequency ablation is an alternative minimal invasive procedure being more famous in easily accessible appendicular skeletal tumors to avoid neural and spinal cord injury due to heat dissipation [10, 11]. Safety distance and use of carbon dioxide or air injection is been advised for thermal protection to neural structures. Ultimately accurate and precise localization of tumor is a mainstay principle for interventional radiology and surgical resection [12].

Intraoperative localization of the tumor nidus remains difficult despite the use of preoperative advance imaging. Traditionally, radiographic C arm-aided open surgical resection of spinal osteoid osteoma and osteoblastoma has been performed. The C arm provides 2-D images with considerable ease of use which was utilized for intraoperative guidance to locate and excise the tumor. C arm can fail to locate the tumor intraoperatively which might demand the need of intraoperative transport to the CT scanner, increase operative time and blood loss, inadequate resection of tumor, increased risk of recurrence. The O arm is a cone beam imaging system which has provisions of 2-D fluoroscopy and 3-D navigation and provides CT images in the operation room. O arm provided a new avenue to localize the spinal lesions and ensure complete resection of the tumor during surgical excision which ultimately reduces blood loss, surgical time ensuring faster recovery and less risk of recurrence, [13, 14] which is also proved in our study (Table 1).

Conclusion

Radiological diagnosis is inconspicuous so detail knowledge about MRI findings of osteoblastoma is of utmost important. Having experience of operating similar cases (spinal osteoblastoma) through the spectrum of evolving radiological advancement in single institute by same surgeon we conclude that radiological advancement from 2D fluoroscopy(C arm) to O arm navigation has improved the surgical management of osteoblastoma in terms of real time accurate localization, intraoperative CT confirmation of complete excision and speedy recovery by minimizing dissection, blood loss and surgical time.

Abbreviations

CT scan	Computed tomography scan
C arm	Two-dimensional image intensifier
O arm	Three-dimensional image intensifier

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Author contributions

SRH was involved in conceptualization; data curation; formal analysis; methodology; software; supervision; validation. SMK contributed to conceptualization; data curation; investigation; methodology; project administration; software; validation; visualization; writing—original draft; writing—review and editing. PDB was involved in data curation; investigation; resources; software; validation; visualization; writing—review and editing. PKS was involved in formal analysis; project administration; resources; software; supervision; validation.

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Availability of data and materials
Not applicable.

Declarations

Consent for publication
The patients were informed that data concerning the case will be submitted for publication and the consent for the same was granted.

Competing interests
The author(s) declare that they have no competing interest.

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