Case Report

Alternative approach to treatment of unusual site giant cell tumor at cervical spine: A case report and review of literature

ABSTRACT

Giant cell tumor (GCT) is an intermediate malignant bone tumor which mostly involves long extremity bones, less commonly involving the spine with sacral predominance. Cervical spine involvement is rare. According to literature, the selective approach for the treatment of GCT is *en bloc* resection with spinal reconstruction. For unusual sites, such as cervical region, which is a mobile spinal segment and critically proximate to the cervical spinal cord, great vessels, and vital organs, it is almost impossible to perform the selective approach for treatment. Alternative approaches in such situations are under investigations. We present a case of C2 vertebral body GCT, who was treated with polymethylmethacrylate intravertebral injection and was followed by adjuvant therapy with denosumab. A 16-year-old boy without any past medical history presented with progressive suboccipital and axial neck pain since 3 months earlier, which had not responded to conservative treatments. There was no neurologic deficit, and pain was significantly controlled. In the 1-year follow-up, no complication and tumor recurrence was seen. Vertebroplasty with bone cement for lytic spinal GCT lesions, followed by adjuvant therapy with denosumab, not only is a less invasive treatment but also has good results in spinal stability, patient recovery, and 12-month recurrence.

Keywords: Cervical spine, denosumab, giant cell tumor, vertebroplasty

INTRODUCTION

Natural history

Giant cell tumor (GCT) is a biologically unpredictable primary bone tumor.[1] According to the WHO 2020 classification, GCT is an intermediate malignant bone tumor with invasion capability to surrounding tissue.[2] It accounts for 5% of all primary bone tumors, mostly involving the appendicular skeleton, of which only 2%–4% occur in the spine.[1] Sacral bone is the most common site of involvement in the spine, while cervical region is the least.[3] In another study, spinal GCTs were reported as common as 2.7%–6.5%.[4] GCT has a female predominance with average presenting age of 20–40 years.[5]

Symptoms

The most common presenting symptoms are pain and limited range of motion. Neural involvement is also frequent and seen in more than 70% of cases.[4]

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Prognosis

The prognosis of GCTs in the mobile spine is worse, in comparison to extremities, due to higher fragility and proximity to the neural elements.[1]

Histopathology

Histologically, GCTs are known as osteoclastoma and are characterized by a hypercellular field consisting of multinucleated giant cells among a population of mononucleated, oval, or round cells.[1] In previous literature, GCTs have been considered benign. This may provide a wrong concept regarding the behavior and progression of these tumors because their osteolytic nature may cause severe damage to surrounding tissues. There are also a 13.5% chance of lung metastasis and a 2% chance of sarcomatous transformation in malignant cases.[1]

Diagnostic methods

Findings of computerized tomography (CT) scan (an expansile osteolytic lesion with cortical insufflation) and magnetic resonance imaging (MRI) (T1 isointense and T2 iso- to hyperintense with peripheral enhancement with gadolinium) are not pathognomonic for the diagnosis of GCTs, so histopathologic investigations on tissue biopsy samples are necessary for definite diagnosis.[4] "H3F3A" mutation is a known specific marker of GCTs and may be a diagnostic confirmation tool for these tumors.[5]

Differential diagnoses

Aneurysmal bone cyst (ABC), simple bone cyst, chondroblastoma, osteoid osteoma, osteoblastoma, osteosarcoma, giant cell reparative granuloma, and brown tumor of hyperparathyroidism are the main differential diagnoses of GCTs.[4]

Treatment

To date, there has been no confirmed algorithm to treat spinal GCTs, which may be due to a lack of clinical trials and comparative studies on such tumors, which, in turn, can be attributable to the rarity of the cases.[1] However, the standard treatment for spinal GCTs, especially in the case of neural involvement, is, so far, surgical procedures including *en bloc* resection, intralesional resection, curettage, or intraoperative adjuvant therapies – such as vertebroplasty or cryotherapy.[4] For recurrence or tumor remnants after surgical resection, radiotherapy, selective embolization, cryotherapy, vertebroplasty, argon plasma coagulation, bisphosphonates, interferon-alpha-2-b, and denosumab are among adjuvant therapies.[4]

As to the pertinent literature, Tsukamoto *et al.*[2] provided a treatment algorithm for malignant and nonmalignant GCTs in a review study conducted on a collection of previous studies.

Outcome

Spondylectomy for *en bloc* resection provides the best long-term prognosis and disease-free survival.[1] Intralesional surgical resection has 72.2% disease-free survival.[1] As GCTs are radiosensitive tumors, adjuvant radiotherapy has been reported to bring about 60%–80% long-term disease control. On the other hand, megavoltage radiotherapy has a great risk of malignant transformation.[1] Despite the already mentioned measures, tumor recurrence has been reported 26%–50% in literature.[4]

In general, several treatment approaches have been utilized with different outcomes[5] that will be discussed in relevant parts of this study. Thus, large-scale prospective studies are required to provide an acceptable treatment algorithm for GCTs.[5]

CASE REPORT

Clinical presentation

A 16-year-old boy without any past medical history presented with progressive suboccipital and axial neck pain since 3 months earlier, which had not responded to conservative treatments. Radiologic investigation revealed a mass in C2 vertebral body and dense process. In MRI examination, the lesion turned out to be a cystic mass in C2 vertebral body, iso-intense in T1 and iso-hyper-intense in T2 with enhancement in gadolinium study [Figure 1]. CT scan also revealed an expansile osteolytic lesion with cortical insufflation [Figure 2]. Following the preliminary diagnosis, due to the unusual site of tumor, the patient was referred to the spine surgery subspecialty center for further investigations and treatment.

In neurologic examination, all muscle powers were intact; no sensory level, sphincter problem, or gate disturbance was detected, and no sign of myelopathy was found. Furthermore, there was not any noticeable problem in family history or social background.

Based on the published literature, open surgical resection methods and radiotherapy were not possible for our case due to unusual location and adjacent vital neurovascular tissues. Besides, due to high probability of local recurrence and, thus, devastating complications, adjuvant therapy was highly indicated for this patient. Furthermore, CT-guided biopsy was not feasible for this patient in our interventional radiology department. Therefore, our planning seminar – consisting spine surgeon, interventional radiologist, pathologist, and oncologist – agreed with open curettage biopsy and pathologic investigation on frozen sections. Vertebroplasty and adjuvant therapy with

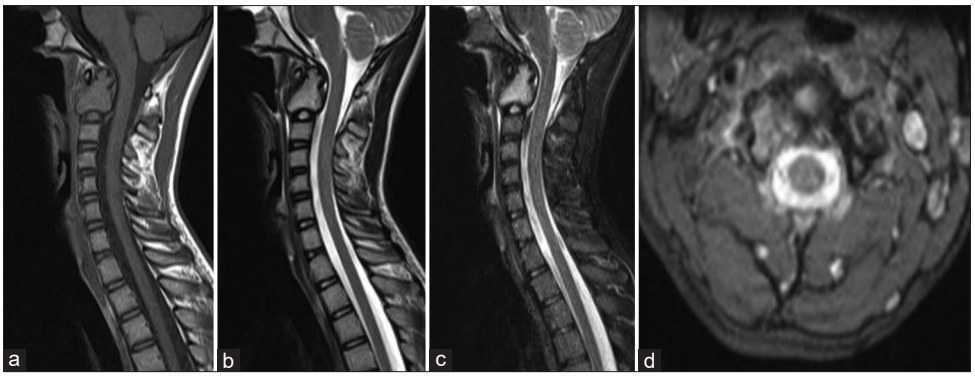

Figure 1: MRI of the cervical spine, showing a well-identified C2 lesion with odontoid process involvement without extension to extradural space. A cystic lesion of the C2 vertebral body that has isointense signal in T1 (a), iso- to hyperintense signal in T2 (b), and enhanced with gadolinium study (c and d). MRI: Magnetic resonance imaging

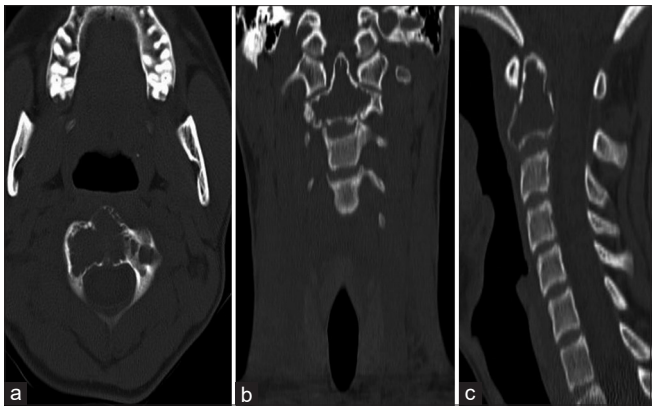

Figure 2: Preoperation cervical spine Computed tomography scan examination, showing an expansile osteolytic lesion with cortical insufflation of C2 vertebral body, involving odontoid process. Axial, coronal, and sagittal views of C2 vertebra from left to right, respectively. CT: Computerized tomography. axial (a), coronal (b), sagittal (c)

denosumab were decided and followed for our patient after pathologic confirmation.

Operative procedure

Following the complete spinal imaging, C2 was confirmed as the only site of involvement, and, thus, the patient was prepared for surgery. Having described the intervention mode, its potential complications, and other possible treatment approaches, informed consent was obtained from both the patient and his parents. As the initial step, under general anesthesia, the patient was situated in proper supine position. After preparing and draping the surgical field, through retropharyngeal approach, C2 vertebral body was exposed under fluoroscopic guidance, and needle biopsy was performed. The sample was sent for frozen sectioning and immediate pathologic investigation, which proved to be GCT. Further pathologic examinations also confirmed the diagnosis [Figure 3]. Using polymethylmethacrylate (PMMA), vertebroplasty was performed for C2 vertebral body and odontoid process. The surgery was completed with no problematic event [Figure 4].

Postoperative course

After proper recovery, the patient was transferred to the ward with rigid cervical collar and was discharged after tolerating mobilization and oral feeding, having significant limiting pain, and without any neurologic deficit. In his 2-week follow-up, adjuvant therapy with subcutaneous injection of 120 mg denosumab every 28 days was started for him. The patient underwent follow-up for pain control, clinical examination, and CT scan investigation every 3 months for local tumor recurrence investigation. After 12 months, there was no tumor recurrence and no neurologic deficit and pain was significantly controlled. In 6-month postoperative CT scan follow-up, areas of new bone formation were detectable around injected bone cement [Figure 5].

We obtained informed consent from the patient and his parents for the publication of this study.

DISCUSSION

The low prevalence of spinal GCTs has limited performing extensive clinical trials and comparative studies to obtain an acceptable treatment algorithm for such tumors.[1] Furthermore, to date, standard treatment for GCT has been surgical resection, yet in cases of tumor recurrence, remnants, or inoperable situations, adjuvant therapies have been successfully applied.[6] Case reports about alternative treatment approaches to spinal GCTs are briefly reviewed [Table 1].

Surgical approaches

En bloc resection and spondylectomy

Spondylectomy to obtain *en bloc* surgical resection, as the main treatment for GCTs, has provided the best long-term prognosis and disease-free survival. On the other hand, *en bloc* surgical resection is not possible for many spinal GCTs due to proximity to the spinal cord and neurovascular

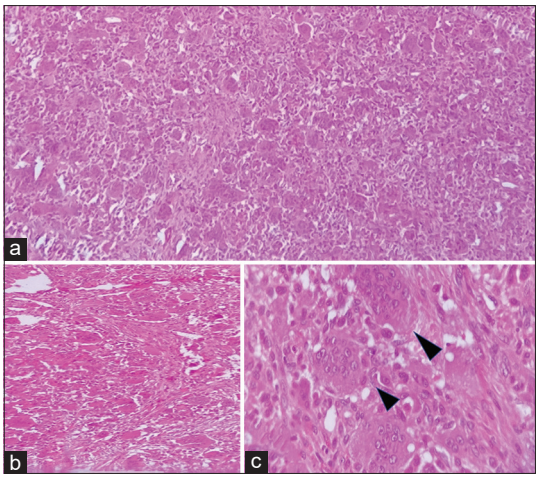

Figure 3: Histopathological evaluation of the lesion. (a and b) Histopathological sections show sheets of tumoral stromal cells admixed with evenly distributed numerous giant cells. Stromal cells show vesicular oval nuclei with conspicuous nucleoli (H and E, ×40, ×100) (c) Giant cells (arrowhead) show numerous nuclei which are morphologically identical to the stromal cells (H and E, ×400)

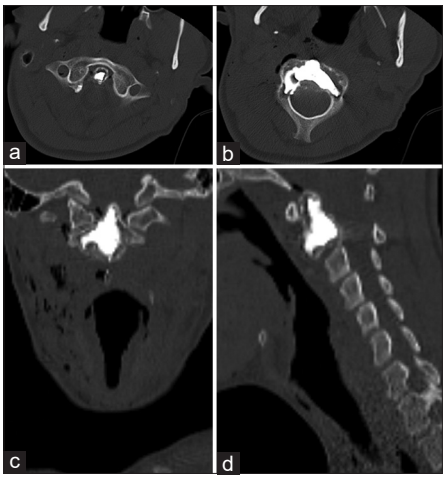

Figure 4: Early postoperation (C2 vertebroplasty) CT scan examination of the cervical spine. Axial, coronal, sagittal, and Scott views from left to right, respectively. CT: Computerized tomography. axial (a,b), coronal (c), sagittal (d)

structures.[5,11] Preoperative embolization before *en bloc* surgical resection facilitates surgery and significantly decreases the intraoperative hemorrhage.[21] Retrospective observational studies show that 35.1% of patients who went under *en bloc* surgical resection have experienced at least one complication.[1] This approach, in conjunction with spinal fixation and reconstruction, is available for the lower lumbar region and is curative for GCTs.[1] For multilevel lesions in the lumbosacral junction, this approach is more challenging and complicated, requiring a multidisciplinary teamwork process. Besides, prior to the surgery, the patient and his/her family should be well informed regarding major morbidities.[1] A case of T11 GCT with associated scoliosis was presented in 2017, treated with preoperative denosumab for 8 weeks and then *en bloc* surgical resection under CT scan navigation. This study showed a beneficial effect of denosumab and CT navigation on facilitating and easing *en bloc* surgical resection.[15]

Intralesional tumor resection

Intralesional surgical resection, providing 72.2% disease-free survival, is an alternative surgical treatment when *en bloc* surgical resection is not possible.[1] For instance, intralesional surgical resection following arterial embolization is the best option in cases where there is a high probability of neural damage through *en bloc* surgical resection, such as sacral GCTs.[22] Besides intraoperative hemorrhage control, preoperative arterial embolization helps extending surgical resection and thus decreases the risk of local recurrence and, therefore, better outcomes are achieved.[23] If utilizing denosumab as neoadjuvant therapy, curettage of tumor margins together with intralesional resection shows a lower local recurrence rate.[24] Whether denosumab can ease the intralesional resection and help preserving important structures such as joints and neurovascular structures is still under question.[24] High rate of local recurrence in GCTs is a challenging and concerning issue. The minimum time duration for the recurrence is predicted as 10 years following the last surgery. To prevent the local recurrence, applying proper treatment strategy and assessing risk factors are crucial *per se*. In such regard, intralesional surgical resection has proved beneficial in local recurrence control.[25]

Minimal invasive approaches

Vertebroplasty

GCT potential for malignancy has caused the treatment approach in spinal forms for complete resection of tumor to be extensive, mostly requiring two-step surgeries – dorsal and ventral. Literature reveals that intralesional curettage and bone cement injection have led to solid fixation. This approach was performed for the first time in 1998 for a case of thoracic spine GCT, leading to significant solid fixation.[26] In another case report of sacral GCT in 2008, 4 mg of zoledronate was administered every 4 weeks following intralesional curettage plus bone cement injection. Within a 2-year follow-up, the patient did not report any disturbing pain, neurologic deficit, or local tumor recurrence.[10] In a retrospective study of 4 sacral GCT cases in 2015, zoledronic acid-loaded bone cement following intralesional curettage was recommended for better local tumor control.[27] For spinal tumors, bone cement injection reduces resistant pains through the mechanisms of mechanical bone stability, destruction of irritated nerve endings, and induction of tumor necrosis.[10] Paul in 2006 proved complete GCT tumor necrosis after vertebroplasty on the basis of radiographic and histologic findings and assumed tumor necrosis to be due to the cytotoxic effect of PMMA and thermal tissue injury of PMMA polymerization process.[20] Therefore, vertebroplasty

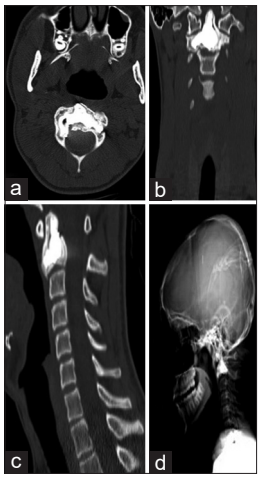

Figure 5: Follow_up CT scan examination of the cervical spine after 12 months. Areas of new bone formation were detectable around injected bone cement. Axial, coronal, sagittal, and Scott views from left to right, respectively. CT: Computerized tomography. axial (a), coronal (b), sagittal (c), scott view (d)

can be regarded as an appropriate alternative treatment when spondylectomy is not feasible.[10] In 2013, a case of sacroiliac GCT underwent anterior-posterior wide tumor resection followed by bone cement injection for spinal reconstruction. According to this experience, bone cement can be taken as an effective alternative and a less invasive reconstructive method rather than complicated expensive fixators and allografts.[28]

Serial embolization

Based on the previous studies, therapeutic embolization without surgical intervention or adjuvant radiotherapy has been effective in treating sacral GCTs in an 8-year follow-up. On the other hand, 10 years of follow-up has shown 31% tumor recurrence for patients who underwent embolization as the only treatment.[1] When used as neoadjuvant therapy before surgical resection of sacral GCT, embolization can reduce the intraoperative bleeding and yield better optimal resection.[2,23] In patients who are at higher risk of surgical complications after *en bloc* resection, intralesional resection following arterial embolization is the best option with good local tumor control.[22,23] In a case series in 2012, serial arterial embolization was reported as an effective alternative treatment in inoperable cases for not only sacral GCTs but also other spinal areas.[21] In addition, Cebula *et al.*, in the same year, reported a case of hypervascular C2 GCT surrounded by ABC, for whom arterial embolization was performed 3 times with ONYX followed by complete tumor resection. Spinal reconstruction was done using C2 vertebral body and odontoid cementoplasty plus anterior C3-prosthesis plate.[18]

Cryotherapy

Müller *et al.*, in 2016, suggested that in patients for whom curettage and adjuvant therapy with denosumab are utilized, better results for local tumor control will be gained by more aggressive curettage plus intralesional phenol, hydrogen peroxide, or liquid nitrogen injection. They also stated that they would prefer cryotherapy with liquid nitrogen.[29]

Nonsurgical Approaches

Treatment with denosumab

Denosumab is a human monoclonal antibody, acting in bone remodeling by bounding to stimulatory receptor: nuclear factor-β ligand receptor activator of nuclear factor kappa-B ligand (RANKL). It was first approved for osteoporosis treatment. Afterward, in 2013, it also received the Food and Drug Administration (FDA) approval for bone metastases and bone tumors including GCT. In the same year, it was successfully used as neoadjuvant therapy for patients with long bone GCTs who could not undergo surgical total resection due to high risk of complications and such severe morbidities as amputation or joint loss. It acts through osteoclast inactivation and, thus, reduces bone resorption.[3,6] According to histological research, GCTs' stroma consists of giant oval osteoclasts, which highly present stimulation receptor for nuclear factor- ligand. This characteristic represents the osteoclastic nature of these tumors, and denosumab, as a monoclonal antibody against this receptor, can be an effective alternative treatment option for GCTs.[27] For extremity GCTs, denosumab is administered for 2 loading doses of 120 mg on days 8 and 15, then after 4 weeks, 120 mg every 4 weeks for 6 months.[3] According to histologic investigations in 2010, denosumab is capable of significantly reducing GCT tumor cells and arresting radiologic tumor progression.[1] Controlling pain (reduction in Visual Analog Score), alleviating surgical resection and curettage, improving functional outcome, reducing intraoperative hemorrhage, and changing the course of disease to latent form are other noticeable effects of this drug. However, due to higher recurrence in patients who were administered with only neoadjuvant therapy with denosumab, adjuvant therapy was also suggested for better local tumor control.[2,6,29] Besides, there is evidence that adding denosumab to GCT curettage improves the outcome and reduces recurrence. It is even better to perform more aggressive curettage and use phenol, hydrogen peroxide, or liquid nitrogen in the site for more local tumor control.[29] In their literature review in 2018, Agarwal *et al*. warned about routine utilization of denosumab in GCT treatment. They stated that using denosumab as neoadjuvant therapy prior to intralesional resection or curettage not only does not improve local tumor recurrence but also raises it. Thus, the questions remain whether or not neoadjuvant therapy facilitates surgical resection and what its proper dose, duration of use, and the best indications could be.[24,14] As recommended, adjuvant denosumab administration is better be kept for patients with a high risk of tumor recurrence, extensive local tumor invasion, close approximation to neurovascular

Table 1: Alternative treatment approach to spine giant cell tumors

Case	Year/place	Age/gender	Involvement	Soft-tissue extension	treatment	Follow-up duration	Local recurrence	Other features
Santiago-Dieppa *et al*.[1]	2014/USA	58 years old/ female	L4 and L5	Positive	L4–L5 spondylectomy + lumbopelvic reconstruction (combined approach)	2 years	Negative	-
Kinoshita *et al*.[7]	2019/Japan	20 years old/ female	L3	Positive	TES	2 years	Negative	Preoperative denosumab injection
Afsoun *et al*.[8]	2018/Iran	32 years old/ female	C6	Positive	*En bloc* resection	-	-	-
Heinrich *et al*.[9]	2019/USA	15 years old/ female	C1	Negative	Transoral tumor resection+subsequent occiput-cervical three posterior instrumented fusion	3 weeks	Negative	Preoperative denosumab injection
Al-Shamary *et al*.[5]	2019/Saudi Arabia	29 years old/ male	T1	Positive	Spondylectomy and multilevel spinal fixation (combined approach)	10 months	Negative	-
Arpornchayanon and Leerapun[10]	2008/Chiang Mai	32 years old/ female	Sacrum	Positive	Intravenous 4 mg zoledronate every 4 weeks for seven courses+curettage and bone cement implantation	2 years	Negative	Curettage and bone cement implantation was performed at the fifth month (after the fourth dose of intravenous zoledronate)
Lee *et al*.[11]	2014/Korea	20 years old/ male	T4	Positive	Decompressive laminectomy and posterolateral fusion of T3--5 + 7 cc PMMA injection at T4	7 years	Negative	-
Wong *et al*.[12]	2020/USA	8 years old/ female	C7	Positive	Percutaneous doxycycline sclerotherapy	10 years	Negative	-
Nakazawa *et al*.[13]	2016/Japan	41 years old// male	C5	Positive	Conservatively with denosumab	2 years	Negative	Involvement of the vertebral artery
Sakuda T *et al*.[31]	2021/Japan	14 years old/ male	C2	Positive	Started on denosumab at 15 years of age and received carbon ion beam therapy	5 years	Negative	Recurrence after surgery (tumor resection and autologous bone grafting
Inoue *et al*.[15]	2017/Japan	35 years old/ female	T11	Positive	TES+preoperative and postoperative denosumab therapy	Every 3 months	Negative	Complicated by idiopathic scoliosis
Sertbaş *et al*.[16]	2019/Turkey	31 years old/ male	C4	Positive	Widely curetted through an anterior approach (corpectomy) + anterior spinal reconstruction	3 years	Negative	-
Law *et al*.[17]	2018/ Singapore	53 years old/ male	C3	Positive	Intralesional resection + postoperative denosumab therapy	4.5 years	Negative	Positive surgical margins
Cebula *et al*.[18]	2012/France	25 years old/ male	C2	Positive	Preoperative onyx embolization followed by a full tumor resection + spinal reconstruction (cementoplasty)	-	-	Colonized by an aneurismal bone cyst/ postoperative zoledronic acid therapy
Liu HC *et al*.[28]	2013/Taiwan	46 years old/ female	Sacrum	Positive	Tumor excision (combined approach) + reconstruction with bone cement	6 years	Negative	S1 nerve root involvement/ preoperative tumor embolization/ postoperative low-dose radiation therapy
Paúl *et al*.[20]	2006/Spain	39 years old/female	L2	Negative	Vertebroplasty+total tumor resection and partial corpectomy	-	-	Complete tumor necrosis subsequent to injection of polymethylmethacrylate

TES: Total en bloc spondylectomy, PMMA: Polymethylmethacrylate

structures, and evidences of lung metastasis. As a result, physicians are highly recommended to take into account the pros and cons of denosumab and consider the warning signs before administering it for GCT treatment.[14] After FDA approval for denosumab administration in GCT patients, an international multicenter clinical trial of its use was started in 2013. The target population were spinal GCT patients (including sacral GCTs), whose disease was in its active phase based on clinical and radiologic evidence. The patients were categorized into three groups, namely surgical unsalvageable giant cell tumors of bone (GCTBs), patient's candidate for surgery but with a high risk of postoperative morbidity, and others who were added from previous studies.[30] The standard treatment for GCT is surgical resection or curettage with intraoperative adjuvant therapy. However, some patients were not good candidates for surgery due to their unusual site of tumor. The results of this study were published in 2020, in which denosumab administration dose was suggested as 120 mg every 4 weeks with 2 loading doses on days 8 and 15. Denosumab was shown to have a beneficial role in spinal GCTs (including sacral GCTs).[30] It is noticeable that more than half of patients with resectable spinal GCTs (including sacral GCTs) benefit a good level of disease control and decide to proceed with denosumab rather than surgical treatment. Randomization could not be done in this study due to low prevalence of the disease.[30] This research, after all, is in favor of using denosumab as an alternative treatment for patients with unresectable GCTs. The safety profile in the subgroup of patients for spinal GCTs (including sacral) was consistent with total population, and no new safety signals were detected.[30]

As to the side effects, there has been no report of jaw necrosis or hypocalcemia in drug complication studies. There were some reports of periapical abscess and periodontal disease in the course of treatment with denosumab, suggesting oral and dental examination before starting the treatment with denosumab. Renal function tests and serum calcium level investigation before starting the treatment and daily Vitamin D (more than 400 IU) and calcium (more than 500 mg) supplement administration during treatment have also been advised.[6]

Although for locally invasive tumors and those resistant to medical treatments, surgical intervention is crucial, it is reasonable to consider nonsurgical treatments for craniovertebral junction and atlantoaxial tumors (benign or malignant) in the first place due to their complex anatomy. It should also be considered that resection of lytic lesions in these areas can lead to spinal instability and alter atlantoaxial angles, endangering nearby neurovascular structures. Therefore, surgical resection depends on spinal fusion and stabilization.[9] Keeping all the aforementioned lines in mind, after considering warnings and specific conditions, denosumab can be applied as adjuvant or neoadjuvant therapy in spinal GCTs (especially the cervical region).

Denosumab (120 mg/month for 2 years) was administered in 2016 for a case of cervical GCT, which was unresectable due to the unusual site and proximity to neurovascular structures. Tumor necrosis and regression showed up in CT scan after a 6-month follow-up, and no tumor recurrence occurred after a follow-up of 2 years.[13]

The first case of successful disease control with denosumab was presented in 2018, who was a 53-year-old patient with cervical GCT, undergoing surgical resection with positive surgical margins. In this patient, the disease remained stable even after reducing the dose of the drug, so it was returned to the previous dose. Hence, denosumab is a good treatment option in cases of unresectable tumors and high risk for severe postoperative morbidity. The ideal dose and duration for GCT treatment and whether or not it causes complete or partial GCT remission is still unknown and requires further research.[17]

In cases of inoperable spinal GCTs and candidates for *en bloc* resection, neoadjuvant therapy with denosumab is preferred,[2,15] and in cases of lung metastasis, "wait-and-see" approach is primarily taken, and treatment with denosumab is suggested for growing tumors.[2]

Radiotherapy

GCT is a radiosensitive tumor; thus, radiotherapy can provide 60%–84% long-term local tumor control.[2] For spinal GCT, 100% treatment response and 98% overall survival are reported in a literature review.[2] However, due to high risk of malignant transformation (33%), radiotherapy is not suggested, especially for young patients. Local tumor recurrence 2 years after radiotherapy is considered malignancy.[2,17] Therefore, it should be kept for instances where surgical intervention is impossible and other alternative options, such as zoledronate, denosumab, and embolization, are not available.[2]

Carbon-ion beam therapy

According to a case report in 2021, in a case of surgically resected cervical GCT with autologous bone graft, local tumor recurrence was recognized following a 4-month follow-up. The patient underwent carbon-ion beam therapy with a 70.4 Gy dose in 32 sessions for 7 weeks, and after 5 years of follow-up, there was no sign of neurologic deficit, disease recurrence, or malignant transformation.[31]

Chemotherapy

Chemotherapy is not generally suggested as a standard treatment option for spinal GCT.[1]

CONCLUSION

Spinal GCT, as a tumor with a high probability of local recurrence and invasion, requires a proper treatment plan to control local recurrence and prevent nearby neurovascular structure damage. The gold standard treatment for this tumor is complete *en bloc* surgical resection. However, in the spine, especially in the cervical region, it is almost impossible due to special anatomic features. Although different alternative treatments have been utilized in this type of tumors, a unified acceptable treatment algorithm has not been given yet because the rarity of spinal GCTs prevents performing large clinical trials and conducting comparative studies. According to our experience, bone cement injection for vertebroplasty in lytic GCT lesions followed by adjuvant therapy with denosumab improves the patient recovery and spinal stability through a less invasive procedure besides no recurrence after 12-month follow-up.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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