The Journal of Veterinary Medical Science

NOTE

Surgery

Vertebral replacement for the treatment of vertebral osteosarcoma in a cat

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J. Vet. Med. Sci.
79(6): 999–1002, 2017
doi: 10.1292/jvms.17-0142

Received: 21 March 2017
Accepted: 20 April 2017
Published online in J-STAGE: 4 May 2017

ABSTRAST. A 7-year-old cat was referred with pelvic limb ataxia. Radiography and CT revealed bone resorption of the L1 vertebral arch, and myelography identified a compressive extradural lesion. The mass was surgically removed and histopathologically diagnosed as giant cell osteosarcoma. Three years later, the recurrent tumor resection and vertebral fixation were performed. Six months later, vertebrectomy was performed to radically excise the recurrent mass and a titanium spinal cage was placed. The cat is alive approximately 5 years after the first surgery. This case report describes vertebrectomy and vertebral body replacement as a radical treatment for feline vertebral osteosarcoma.

KEY WORDS: cat, neurosurgery, osteosarcoma, vertebral replacement, vertebrectomy

A 7-year-old, castrated male, American Shorthair cat was referred to the Animal Medical Center of Gifu University with a 40-day history of progressive pelvic limb ataxia (day 1). On physical examination vital parameters were normal and the cat had no pain. The cat's mental status was alert during neurological examination, and general proprioceptive ataxia was noted in the pelvic limbs. Postural reactions were absent in the pelvic limbs. Spinal reflexes of all limbs and cranial nerve functions were unremarkable. Therefore, the neuroanatomical localization was the T3-L3 spinal cord segment. Radiographs of the lumbar spine showed bone lysis of the left L1 vertebral arch (Fig. 1A). Computed tomography (CT) (Asteion Super 4®, Toshiba, Tochigi, Japan) was performed to further evaluate the vertebral lesion and spinal cord compression (Fig. 1B). Myelography of the thoracic and lumbar spine was performed by subarachnoid injection of iohexol contrast medium (Omnipaque 240®, Daiichi Sankyo Propharma, Tokyo, Japan), 0.4 ml//kg body weight at the L4-5 intervertebral space. CT myelography revealed an extradural and lytic mass in the left vertebral arch of L1, which invaded the spinal canal and severely compressed the spinal cord (Fig. 1C). There was no evidence of metastatic lesion in the thoracic and abdominal organs.

On day 8, surgical removal of the mass was performed by a left dorsal approach to the L1 vertebra. The vertebral mass was identified and easily excised using a rongeur and surgical burr (Fig. 1D). Immediately after mass removal, the spinal cord appeared grossly normal and returned to its normal position. Histopathology demonstrated that the lesion was composed of numerous scattered nests of multinucleated giant cells and multifocal islands mineralized foci of osteoid, which led to the final diagnosis of giant cell osteosarcoma (Fig. 1E). The cat exhibited noticeable improvement in neurologic and motor function in the pelvic limbs four weeks after surgery. Postoperative radiotherapy of the L1 region was initiated on day 29 (6 Gy once a week, total 30 Gy) until day 77. The cat was presented free of clinical signs and able to return to the lifestyle it had prior to the onset of clinical signs for three years.

The cat presented with progressive ataxia and decreased activity on day 1,087, and a neurological examination detected reduction of postural reactions in the pelvic limbs. CT showed the presence of a bony mass in L1 left vertebral arch and vertebral body with areas of bony lysis and compression of the spinal cord from the left side. There was no evidence of metastatic lesion. CT-guided fine-needle aspiration of the lesion was performed and cytology confirmed the recurrence of the giant cell osteosarcoma. Extended hemilaminectomy was performed to decompress the spinal cord, and the T13 and L2 vertebrae were secured in order to stabilize the spinal column on day 1,106. After left dorsal approach, the L1 vertebral arch and vertebral body

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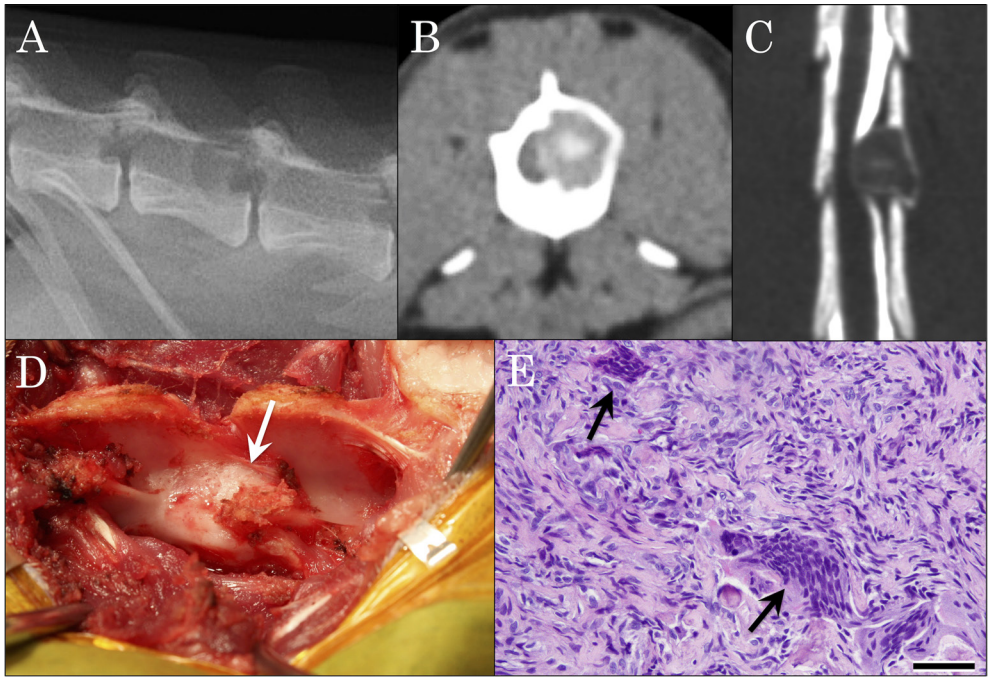

Fig. 1. Diagnostic imaging, macroscopic observation, and microscopic observation of the L1 vertebra at the first surgery. A lateral view of a plain radiograph revealed bone lucency of the vertebral arch of L1 (A). An axial CT image showed the presence of the osteolytic mass lesion, which appeared to arise from the left vertebral arch and extended medially into the spinal canal (B). A coronal reconstruction image of CT myelography showed that the spinal cord was severely compressed by the extradural mass lesion (C). After the detachment of paraspinal muscles, the lateral bulging of the left vertebral arch of L1 was clearly observed (arrow) (D). A histopathological examination showed that the removed tissue consisted of spindle-shaped cells and eosinophilic osteoid, leading to the diagnosis of osteosarcoma (E). Multinucleated giant cells (arrows) were dispersed throughout the tumor (HE; bar=20 μm).

were resected using an ultrasonic bone aspirator. The T13 and L2 vertebrae were secured with two cortical screws inserted in each vertebra and polymethylmethacrylate (Surgical Simplex P®, Stryker Japan, Tokyo, Japan) from the right side in order to stabilize the spinal column. The cat's gait improved one month after the second surgery; however, ataxia of the right hindlimb persisted.

On day 1,295, the cat's gait remained ataxic on the right hindlimb and progressive urinary incontinency was noted. Follow-up CT revealed recurrence of the bony mass, which compressed the spinal cord. There was no evidence of metastatic lesion. On day 1,337, vertebrectomy and vertebral body replacement was performed in order to radically excise the recurrent mass and decompress the spinal cord. The cat was premedicated with atropine sulfate (Tanabe Pharma Co., Osaka, Japan) 5 μg/kg IV, midazolam (Dormicum®, Astellas, Tokyo, Japan) 0.2 mg/kg IV and ketamine hydrochloride (Ketalar®, Daiichi Sankyo Propharma, Tokyo, Japan) 2 mg/kg IV and induced with alfaxalone (Alfaxan®, Meiji Seika Pharma Co., Ltd., Tokyo, Japan) 0.5 mg/kg IV. Fentanyl (Janssen Pharmaceutical K.K., Tokyo, Japan) 15–20 μg/kg/hr continuous rate infusions (CRI), ketamine hydrochloride 0.6–0.8 mg/kg/hr CRI and medetomidine (Domitor®, Nippon Zenyaku Kogyo Co., Fukushima, Japan) 0.5 μg/kg/hr CRI were administrated for pain control. Isoflurane (Isoflu®, DS Pharma Animal Health Co., Osaka, Japan) in oxygen was used for maintenance using mechanical ventilation. After left dorsal approach, the L1 vertebral arch was resected by hemilaminectomy using a rongeur and an ultrasonic bone aspirator under an operating microscope. The vertebral body and spinous process of L1 were resected using a rongeur and an ultrasonic bone aspirator under intraoperative CT guidance (Fig. 2A). The T13/L1 and L1/L2 intervertebral discs were removed using a rongeur and an ultrasonic bone aspirator. The nerve roots and peripheral nerves of T13 and L1, which were compressed by the bony mass and suspected to have lost their functions, were removed. After removal of the L1 vertebra, the spinal cord returned to its normal position. A titanium spinal cage (Pyramesh cage®, Medtronic Japan Co., Tokyo, Japan)(diameter 13 mm) filled with β-Tricalcium phosphate (Osferion®, Olympus Terumo Biomaterials, Tokyo, Japan) was placed into the site of the removed vertebral body (Fig. 2B and 2C). The cage was shaped to have wings on caudal and cranial ends to secure it using 2.0 mm cortical screws to the vertebral bodies of T13 and L2 in order to achieve mechanical stabilization. Postoperative CT and radiography confirmed that the positioning of the cage and screws, alignment and apposition of the cage with the adjacent vertebrae were appropriate (Fig. 2D and 2E). Fentanyl 3 μg/kg/hr CRI, ketamine hydrochloride 0.14 mg/kg/hr CRI and prednisolone (Prednisolone®, Tamura-Seiyaku Co., Tokyo, Japan) 0.5 mg/kg SC were administered for post-operative pain management and cefazolin sodium hydrate (Cefamezina®, Astellas) 20 mg/kg IV was administered for antibacterium. Histopathology of the resected tissue confirmed recurrence of the giant cell osteosarcoma.

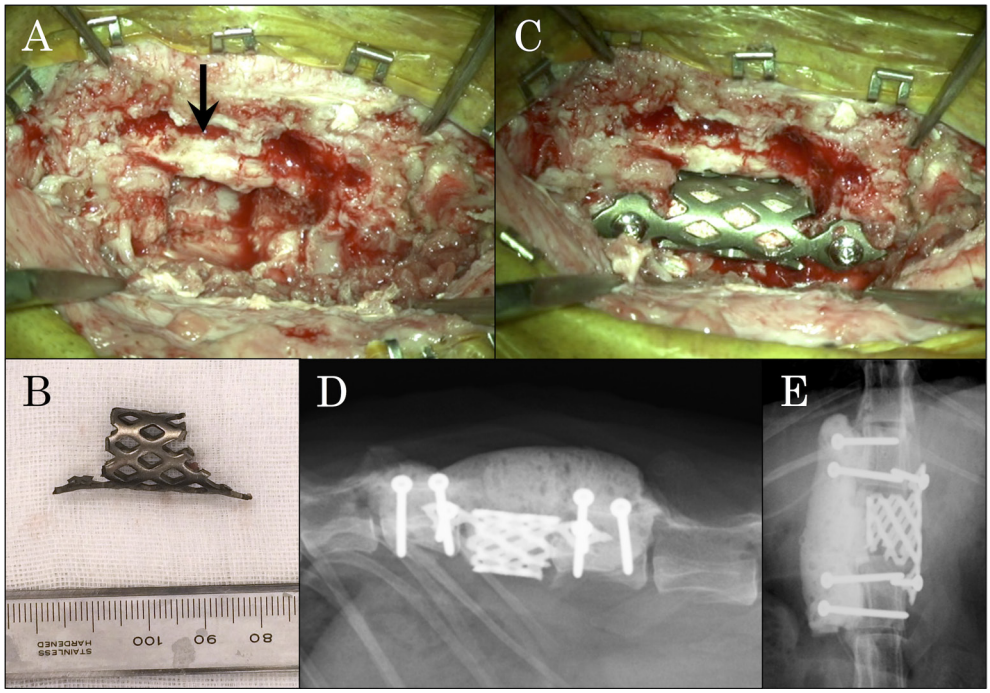

Fig. 2. Vertebrectomy performed at the third surgery. The spinal cord (arrow) was fully exposed after the removal of all components of the L1 vertebra (A). Pyramesh cage (B) filled with β-Tricalcium phosphate was inserted and secured by 2.0 mm cortical screws to the vertebral body of T13 and L2 (C). Postoperative radiographs confirmed that the positioning of the cage and alignment of the cage with the adjacent vertebrae were considered appropriate (D, E).

After vertebrectomy and vertebral body replacement, the cat was transiently non-ambulatory of hindlimbs and lost bladder control. On day 1,372, the cat was not able to stand up and urinate by himself. On day 1,561, the cat was able to walk by pelvic limb with assistance. On day 1,764, the cat was able to stand up by himself, walk with ataxia and urinate after stimulation of his penis. Follow-up CT, which performed on day 1,561, 1,764 and 1,968 showed appropriate alignment of the cage with the adjacent vertebrae. The cat is alive over 5 years and 4 months following the first surgery without obvious recurrence of the tumor.

The incidence of primary bone tumors has been reported to be between 3.1 and 4.9 per 100,000 cases and osteosarcoma comprises 70 to 80% of primary bone tumors in cats [4]. Osteosarcoma occurs more frequently in the appendicular skeleton than in the axial skeleton [2, 4]. Since axial osteosarcoma originates most commonly from the skull and pelvis, only a few studies have described vertebral osteosarcoma in cats [5, 8, 10]. Cats with axial osteosarcoma have a median survival of 5.5 to 6.0 months [2, 4]. In these studies, the metastatic rate was between 5 and 10%. It has been speculated that feline osteosarcoma is less aggressive than its canine counterpart and that amputation may be curative in appendicular cases. On the other hand, the complete resection of axial osteosarcoma is challenging due to the tumor location and potential risks for local invasion [2, 4, 6]. In our case, although the tumor had not recurred for three years after the first surgery, regrowth of the bony mass necessitated the second surgery. Even with the extended hemilaminectomy performed at the second surgery, the recurrence of the tumor was confirmed, which inspired us to perform vertebrectomy and vertebral body replacement to achieve long-term local control.

To the best of our knowledge, this is the first clinical report of vertebrectomy and vertebral body replacement on a feline vertebra. The goals of spinal tumor treatment are tumor removal, spinal stabilization, and neural tissue decompression. In human, total *en bloc* spondylectomy (TES) is recommended to achieve complete removal of the tumor and all the affected vertebrae, with normal tissue as margins, without violation of the tumor capsule [11–14]. However, TES may be too damaging to undertake in some cases, because of the proximity of vital structures to the vertebrae. In these cases, intralesional resection might be the alternative choice, such as total/partial laminectomy, total/partial vertebral body resection, piece-meal resection and curettage and vertebrectomy [3, 9]. Vertebrectomy is a surgical technique to achieve improvement in pain and neurological status, maintenance of spinal alignment, and to minimize local recurrence [1, 7], therefore surgeons may prefer vertebrectomy for patients who have severe complication risks [1, 7]. The cat in the present report had paresis in the pelvic limbs and dysuria, but no metastatic lesions in the adjacent vertebrae or other organs in the thorax and abdomen. To avoid risks of spinal surgery such as mechanical or vascular injury to the spinal cord and mechanical instability of the spine, vertebrectomy was considered appropriate. In our case, surgical stress of vertebrectomy and vertebral body replacement might have caused temporal ataxia and urinary incontinence. The life expectancy must be assessed for individual cases before this surgical technique is chosen. Vertebrectomy may be indicated for cases with spinal tumors with low risk of metastasis or vertebral anomalies.

Since there is no dedicated device for vertebrectomy and vertebral body replacement in small animals, we used a titanium spinal

cage designed for vertebral replacement and stabilization in humans. This implant was suitable for the purpose of our surgery in that the cage was available in a variety of diameters and was easy to shape to the defect site of the vertebra during surgery. The primary goal of the surgery in our case was to completely remove the remaining tumor and provide support across the defect. Since the stabilization of the adjacent vertebrae (i.e. T13 and L2) had been achieved by cortical screws and polymethylmethacrylate at the second surgery, removal of the L1 vertebra was safely performed in our case. Although the mechanical strength of the cage may not be required in small animals as much as for human use, a careful follow-up of the animal is necessary since there is currently no evidence of the long-term safety and stability of this fixation technique in small animals.

We report the first clinical application of vertebrectomy and vertebral body replacement using a titanium spinal cage on a feline vertebra. Since the cat described herein has remained alive for more than five years following the first surgery, the life expectancy of feline osteosarcoma cases might be significantly prolonged if complete tumor resection is achieved. In conclusion, vertebrectomy and vertebral body replacement are feasible and might be an alternative treatment strategy for feline vertebral osteosarcoma.

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