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CASE REPORT

Companion or pet animals

Cranioplasty using castor oil–based polyurethane in a dog with Grade II multilobular osteochondrosarcoma

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Abstract

Multilobular osteochondrosarcoma is an uncommon tumour that affects the flat bones of the skull. Surgical removal of these lesions often results in large osseous defects that require reconstruction using conventional materials or metallic implants. Castor oil–based polyurethane appears to be biocompatible and nonimmunogenic; however, its osteointegrative properties remain uncertain. A 4-year-old Boxer dog was diagnosed with a Grade II multilobular osteochondrosarcoma located in the calvarium, along with a solitary pulmonary nodule. The tumour was removed by craniectomy, and the resulting osseous defect was repaired using castor oil–based polyurethane. Local tumour recurrence and enlargement of the pulmonary nodule were observed 5 months after surgery, despite chemotherapy. The survival time was 7 months. Computed tomography was useful for preoperative tumour characterisation, postoperative assessment of the polymer, and detection of pulmonary metastasis. This report demonstrates that cranioplasty using castor oil–based polyurethane cement may be an alternative option for the reconstruction of skull defects in small animals.

KEYWORDS
bone defects, calvarium, *Chondroma rodens*, cranioplasty, polymer, skull

BACKGROUND

Multilobular osteochondrosarcoma is an uncommon tumour that occurs primarily in the flat bones of the skull, including the mandible, maxilla and calvarium.[1–4] This tumour is most commonly observed in medium- to large-breed dogs, although cases have also been reported in small-breed dogs.[1,3–10] Surgical removal of lesions located in the calvarium often results in large osseous defects and exposure of neural tissue.[6,7,10,11] Reconstruction of these skull defects should be performed using materials that are highly malleable and have low thermal and electrical conductivity.[6] This case report describes the clinical and surgical management of a dog with a Grade II multilobular osteochondrosarcoma of the calvarium that underwent cranioplasty using castor oil–based polyurethane.

CASE PRESENTATION

A 4-year-old, 26-kg, entire, female Boxer dog was presented to the Veterinary Hospital with a growing skull mass that had been noticed approximately 2 months earlier (Figure 1a). According to the owner, the dog exhibited no other clinical signs. Physical examination revealed a large, firm, immobile, nonpainful, protuberant mass arising from the calvarium. No neurological abnormalities were detected.

INVESTIGATIONS

Radiographs of the head revealed an irregular, mineralised mass involving the frontal and parietal bones, with a heterogeneous, popcorn-like appearance, suggestive of multilobular osteochondrosarcoma. Sequential transverse images of the head were obtained to evaluate the extent of the mass, using a spiral computed tomography (CT) scanner (Shimadzu SCT-7800CT). Scanning parameters were 120 kVp, 150–180 mA, 2.0–3.0 mm collimation, 2:0 pitch and a 1-second scan time. CT revealed an expansile mass with extensive granular mineralisation, located dorsally and involving the frontal bone and central region of the parietal bone, with evidence of invasion of the temporal muscle. The mass measured approximately

LEARNING POINTS/TAKE-HOME MESSAGES

- The castor oil–based polyurethane cement may be suitable for filling bone defects.
- The castor oil–based polyurethane cement may represent a viable option for skull reconstruction in small animals.

11 cm in the ventrodorsal dimension, 6 cm in the mediolateral dimension, and 8.7 cm in the rostrocaudal dimension. Despite lysis of the frontal and parietal bones, the mass did not invade the brain tissue (Figure 2).

Thoracic radiographs, obtained concurrently with the skull radiographs, showed no evidence of pulmonary metastasis. However, CT examination revealed a solitary pulmonary nodule measuring 0.4 cm in maximum diameter in the caudal portion of the right caudal lung lobe. The scanning parameters were 100 kVp, 120 mA, 1.0 mm collimation, 2:0 pitch and a 7-second scan time. Despite the possibility of pulmonary metastasis, the owner opted for surgical treatment.

DIFFERENTIAL DIAGNOSIS

Other differential diagnoses include osteosarcoma and other primary bone neoplasms, as well as inflammatory lesions of various aetiologies, including bacterial and fungal osteomyelitis. However, the granular appearance of the lesion in the present case was consistent with the suspected diagnosis.[12]

TREATMENT

Premedication consisted of fentanyl (5 μg/kg intramuscularly; Fentanest, Cristalia). Anaesthesia was induced with propofol (4 mg/kg intravenously [IV]; Propovan, Cristalia) and maintained with isoflurane under controlled ventilation. The dog was positioned in sternal recumbency, with the head supported on a pad to prevent jugular compression. The nose was secured to the operating table with tape to minimise movement. The operating table was tilted to elevate the head by approximately 30°.

An H-shaped skin incision was made over the mass, extending from the frontal region to the external occipital protuberance. The soft tissues surrounding the mass were dissected. A craniectomy involving the frontal and parietal bones surrounding the mass was performed using an oscillating saw, leaving an approximately 5 mm margin of grossly normal bone. The tumour was partially fragmented during surgical removal. The dura mater remained intact (Figure 1b). The resulting skull defect was repaired using castor oil–based polyurethane. The prepolymer was mixed with the polyol component to initiate polymerisation, producing a malleable compound that was immediately moulded by hand and fitted into the bone defect (Figure 1c,d). The temporal

FIGURE 1 Clinical appearance of the expansile lesion in the skull (a). Skull bone after exposure and resection of the tumoural mass. Note the dura mater (*), which remained intact (b). Castor oil–based polyurethane resin kit, composed of a liquid component derived from castor oil and a hardening prepolymer (c). Immediate postoperative appearance with the bone defect filled by the previously moulded polymer (d).

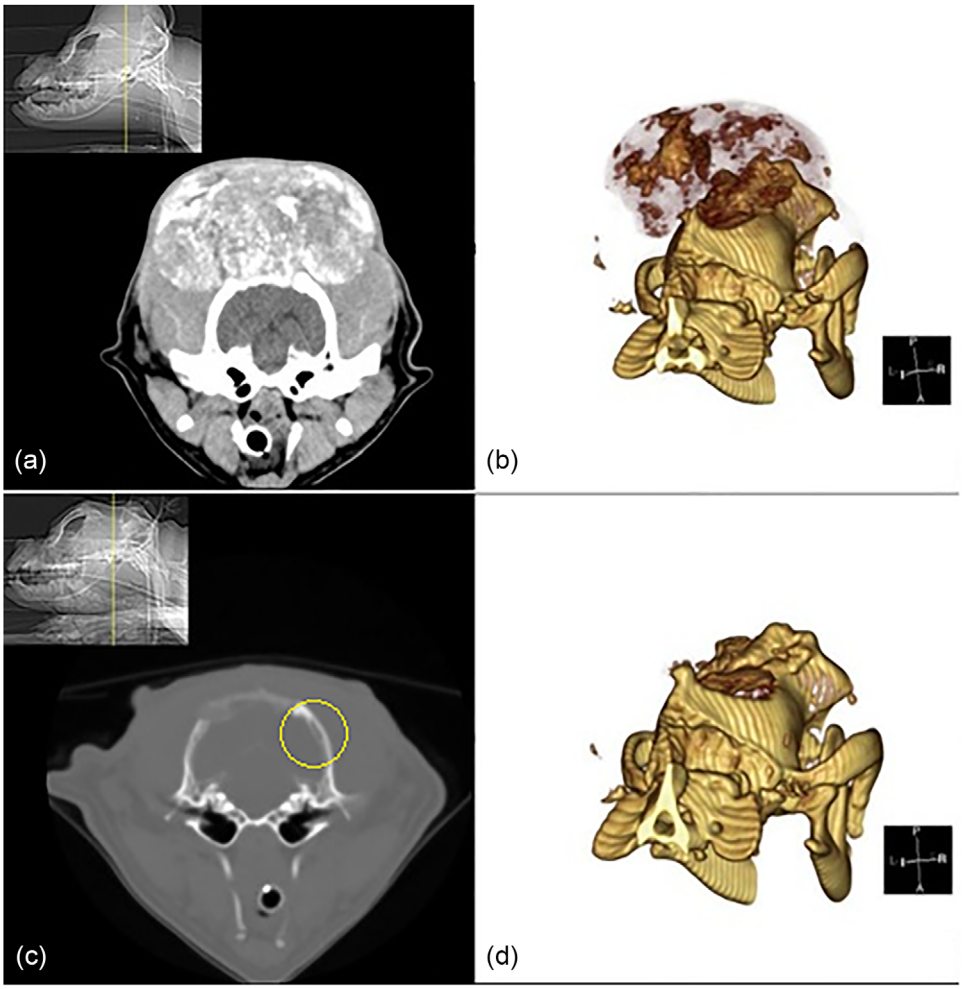

FIGURE 2 Head of 4-year-old Boxer with Grade II multilobular osteochondrosarcoma. Preoperative computed tomography (CT) image (bone window transverse plane) and three-dimensional (3D)-CT image reconstruction showing an expansile mass with extensive granular calcifications, located at the frontal bone and central area of the parietal bone (a and b). Postoperative CT image (bone window, transverse plane) and 3D-CT image reconstruction showing the filling of the bone defect with the castor oil–based polyurethane cement (c and d). Note the yellow circle in (c) demonstrating small lytic areas, suggestive of local tumour recurrence. A: Ventral; P: Dorsal; I: Caudal.

muscles were apposed along the midline using monofilament nylon in a simple interrupted pattern. Subcutaneous tissues were closed using a continuous pattern, and the skin was closed with simple interrupted sutures using monofilament nylon. Ceftriaxone (30 mg/kg twice a day [BID]; Ceftriaxona, Teuto) was administered preoperatively and continued for 7 days postoperatively. Meloxicam (0.1 mg/kg once a day; Maxicam, Ourofino) was administered for 5 days postoperatively. Tramadol hydrochloride (0.2 mg/kg three times a day; Cloridrato de tramadol, União Química) and carprofen (2.2 mg/kg BID; Rimadyl, Zoetis) were administered for 4 and 7 days, respectively.

OUTCOME AND FOLLOW-UP

Histopathological analysis confirmed a Grade II multilobular osteochondrosarcoma, with tumour cells present at the deep resection margins (Figure 3). No postoperative complications were observed. Carboplatin (300 mg/m^2 IV; B-Patin, Blau Farmacêutica) was initiated 15 days after surgery and administered every 21 days for a total of four y doses.

After surgery, the dog recovered well, with no clinical abnormalities. Neurological examination revealed no deficits. At 5 months postoperatively, CT examination revealed local tumoural recurrence at the margin of the bone defect filled with the polymer, as well as an increase in the size of the pulmonary nodule, which measured 0.6 cm in maximum diameter (Figure 2). The polymer implant was visible on CT images of the dorsal calvarium, where it was closely associated with the frontal and parietal bones, and measured approximately 3.5 mm in thickness. The polymer showed lower attenuation than bone, with an attenuation coefficient of approximately 300 HU.

The owner elected to discontinue further treatment, and the dog died 2 months later.

DISCUSSION

The clinical signs of multilobular osteochondrosarcoma may vary depending on tumour's location and degree of invasion.[1,2,10,13,14] Neurological signs may develop when the tumour invades or compresses the underlying neural tissue.[1,2,6,8,14] In the present case, the dog showed no neuro-

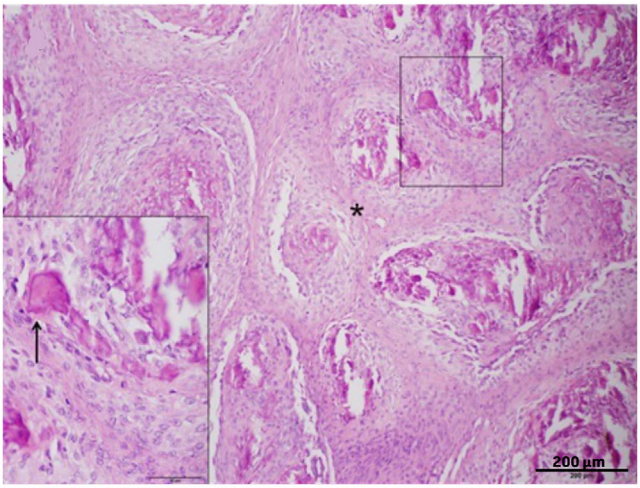

FIGURE 3 Histopathological view of Grade II multilobular osteochondrosarcoma in a 4-year-old Boxer. The lobules contain islands of bone matrix at the centre (arrow—haematoxylin and eosin [HE] 400×) surrounded by cartilaginous tissue separated by a thin septum composed of elongated cells and small blood vessels (*). HE 100×.

logical abnormalities, which was consistent with the CT and intraoperative findings.

Radiographically, multilobular osteochondrosarcoma of the skull typically appears as a mass, with nodular or stippled mineralised opacities associated with areas of osteolysis.[1,15] CT findings in the calvarium include loss of normal bone architecture and a lobulated, round-shaped mass with a granular appearance and heterogeneous bone attenuation.[8–10,12,13,16] Similar radiographic and CT features were observed in the present case. Moreover, CT and magnetic resonance imaging are useful for assessing the extent of brain compression, bone invasion and soft tissue involvement,[13,15] as observed in this case.

Distant metastases have been reported in 56% of canine multilobular osteochondrosarcoma cases,[7] with the lungs being the most frequently affected site.[10] Other reported metastatic sites include the brain, kidneys, pancreas, ribs and long bones.[1,7] In the present case, CT was more sensitive than radiography for detecting a pulmonary lesion suspected to represent metastatic disease.

Reconstruction of calvarial defects following tumour excision has been performed using bone allografts, polymethylmethacrylate, polypropylene mesh, polyetheretherketone and metallic implants.[6,8,9,11,15,16] In the present case, castor oil–based polyurethane combined with calcium carbonate (Bioosteo, Biomecânica) was used. Castor oil–based polyurethane appears to be biocompatible and nonimmunogenic; however, its osteointegrative properties remain uncertain.[17–19] In the present case, postoperative CT showed that the polymer was closely apposed to the frontal and parietal bones, with poorly defined margins, suggesting close integration with the surrounding bone. However, a postmortem histological analysis was not performed to confirm osteointegration.

This material also generates a minimal exothermic reaction during polymerisation, thereby reducing the need to protect the brain and adjacent tissues from thermal injury. It provides an adequate physical barrier and possesses adhesive properties that eliminate the need for a fixation system,[6,11,16,19] as observed in this case. Although castor oil–based polyurethane requires polymerisation, it does not necessarily increase surgical time, unlike polymethylmethacrylate, which often requires intraoperative moulding.[20] Compared with polyetheretherketone implants, castor oil–based polyurethane is more compatible with diagnostic imaging modalities due to its lower attenuation on CT and lighter weight, which may improve comfort for the animal.[16]

In skull tumours, local recurrence has been associated with incomplete surgical margins, tumour grade and tumour location.[1,7,13] In recurrent or long-standing cases, osteochondromas may also undergo malignant transformation.[3] Among dogs treated with surgery alone or surgery combined with adjuvant therapy, recurrence rates of 58% in a series of 12 cases[1] and 47% in a series of 34 cases[7] have been reported. In the present case, incomplete deep surgical margins[1,7,13] and intraoperative tumour fragmentation[5] may have contributed to local tumoural recurrence. In one study, incomplete deep margins were observed despite grossly disease-free surgical margins of 10 mm.[13] The use of 3D-printed resection guides may help reduce the risk of local tumour recurrence[11,13]; however, intraoperative tumour fragmentation may still facilitate the dissemination of tumour cells.

Although the use of adjuvant chemotherapy for multilobular osteochondrosarcoma is not well established,[1,6,7,10,16] carboplatin-based chemotherapy was administered in the present case due to pulmonary metastasis and compromised surgical margins identified by histopathological analysis. Carboplatin is considered an effective treatment for various sarcomas[21] and has lower nephrotoxic potential than cisplatin.[22] In another study, metronomic chemotherapy was associated with more favourable long-term outcomes.[16]

High-dose definitive radiotherapy combined with cranioplasty has been reported as a promising alternative for the treatment of multilobular osteochondrosarcoma, with survival times ranging from 12.7 to 24 months. However, radiotherapy may induce toxicity in adjacent tissues, particularly the eyes.[10] Reported survival times for Grade II tumours range from 28 to 1487 days, with a median of 520 days; however, these data include tumours located in both the calvarium and other anatomical sites.[7] The development of metastases appears to be correlated with the degree of malignancy and significantly affects survival time.[10] In one study, pulmonary metastasis developed approximately 6 months after surgery, with euthanasia performed 14 months postoperatively.[13] In the current case, survival time was 210 days.

This case describes an uncommon approach to cranioplasty for multilobular osteochondrosarcoma cranioplasty using castor oil–based polyurethane combined with carboplatin chemotherapy. The castor oil–based polyurethane cement was suitable for filling the bone defect, and may represent a viable option for skull reconstruction in small animals. However, no apparent survival benefit could be attributed to carboplatin administration in the present case.

AUTHOR CONTRIBUTIONS

Victor José Vieira Rossetto and **Sheila Canevese Rahal** conceived and designed the project. **Victor José Vieira Rossetto** and **Samanta Aires Celeste** acquired the data. **Vania Maria de Vasconcelos Machado** analysed the images examinations. **Viciany Erique Fabris** analysed the histopathological examination. **Victor José Vieira Rossetto** and **Sheila Canevese Rahal** interpreted the data and wrote the paper.

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

ETHICS STATEMENT

This is a clinical case report and, as such, does not require any formal ethical approval. Informed owner consent was obtained for all procedures performed.

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