The Journal of Veterinary Medical Science

NOTE

Surgery

Mid-to-caudal partial hemipelvectomy with limb preservation for ischial tumor in a dog

Yoshifumi ENDO[1,2], Toshikazu SAKAI[1)]*, Sho FUKUI[1], Ai HORI[1], Ryosuke ECHIGO[2], Satoru MATSUNAGA[2] and Tsuyoshi KADOSAWA[1]

[1]School of Veterinary Medicine, The Rakuno Gakuen University, 582 Bunkyodai Midorimachi, Ebetsu-shi, Hokkaido 069-8501, Japan
[2]Japan Animal Referral Medical Center, 2-5-8 Kuji, Takatsu-ku, Kawasaki-shi, Kanagawa 213-0032, Japan

J. Vet. Med. Sci.
84(2): 218–222, 2022
doi: 10.1292/jvms.21-0414

Received: 23 July 2021
Accepted: 28 November 2021
Advanced Epub:
13 December 2021

ABSTRACT. A 10-year-old spayed female Golden Retriever was referred for hindlimb lameness. A firm mass was palpated over the right caudal pelvis. Computed tomography revealed an osteolytic bone region and an associated periosteal reaction in the ischium, including the acetabulum. The histological diagnosis was sarcoma of unknown origin. A mid-to-caudal partial hemipelvectomy was performed to remove the mass. Femoral head and neck osteotomy was performed to allow hindlimb preservation. Following surgery, the dog regained satisfactory hindlimb use over time and was alive for 821 days with no recurrence or metastatic disease. This report indicates that mid-to-caudal partial hemipelvectomy with femoral head and neck osteotomy is technically feasible and allows for tumor control with preservation of the hindlimb and its function.

KEY WORDS: dog, femoral head and neck osteotomy, limb preservation, mid-to-caudal hemipelvectomy, pelvic tumor

A hemipelvectomy is a complex and aggressive surgical procedure that is indicated for the treatment of tumors involving the pelvis and surrounding soft tissue in severe pelvic trauma or malunion [6, 10]. Hemipelvectomy is categorized as total or partial (subtotal) hemipelvectomy according to the extent of resection [2, 10]. Mid-to-caudal partial hemipelvectomy (caudal external hemipelvectomy) generally involves the hemipelvis from the pubic symphysis or portion of the ischium to the mid ilium and includes amputation of the ipsilateral hindlimb [2, 10]. There is limited information on limb-sparing mid-to-caudal partial hemipelvectomy. Mid-to-caudal hemipelvectomy in combination with femoral head and neck osteotomy was reported in three dogs with pelvic fractures showing pelvic stenosis [1]. However, detailed information on the surgical procedure and postoperative gait is not available. There is also no reported evidence that this procedure has been applied to tumor-bearing dogs that require pelvic resection involving extensive surrounding soft tissue as the surgical margin. This case report describes a mid-to-caudal hemipelvectomy and concurrent femoral head and neck osteotomy in a tumor-bearing dog along with postoperative hindlimb functional and oncologic results.

A 10-year-old female spayed Golden Retriever weighing 27 kg was referred to the veterinary teaching hospital of Rakuno Gakuen University, with a 2-week history of right hindlimb lameness. On the day of referral to the hospital (day 1), the dog showed weight-bearing lameness with occasional non-weight-bearing lameness. The physical examination revealed moderate atrophy of the right hindlimb muscle and a palpable firm mass over the right caudal pelvis at the level of the ischium. No neurologic deficits were observed in any limb. The radiographs showed a focal region of osteolysis in conjunction with a periosteal reaction in the ischium. The ischial mass was fully staged and assessed by thoracic and abdominal computed tomography (CT) under general anesthesia. Unenhanced images showed a mixed productive and osteolytic bone region in the right ischium. Contrast-enhanced images showed enhancement of the soft tissue component of the ischial lesion (Supplementary Fig. 1A). The lesion was centered on the body of the ischium and extended from the cranial to the caudal rim and medial aspect of the acetabulum, caudally to the ischial table (Fig. 1A). Medullary extension of the lesion was observed in the pubic and ischial bones. The lesion was mainly in contact with the internal obturator, external obturator, and gemelli muscles. Although hip dysplasia was associated with osteophytes, no direct effect of the lesion was observed on the head of the femur, lunate surface of the acetabulum, and acetabular fossa (Supplementary Fig. 1B). There was no evidence of metastasis in the thoracic or abdominal organs. Following CT evaluation, a bone biopsy of the mass was performed using a Jamshidi bone biopsy needle. The histological diagnosis was sarcoma, however, there was insufficient histological evidence to identify the origin and to rule out osteosarcoma and chondrosarcoma.

*Correspondence to: Sakai, T.: t-sakai@rakuno.ac.jp
(Supplementary material: refer to PMC https://www.ncbi.nlm.nih.gov/pmc/journals/2350/)

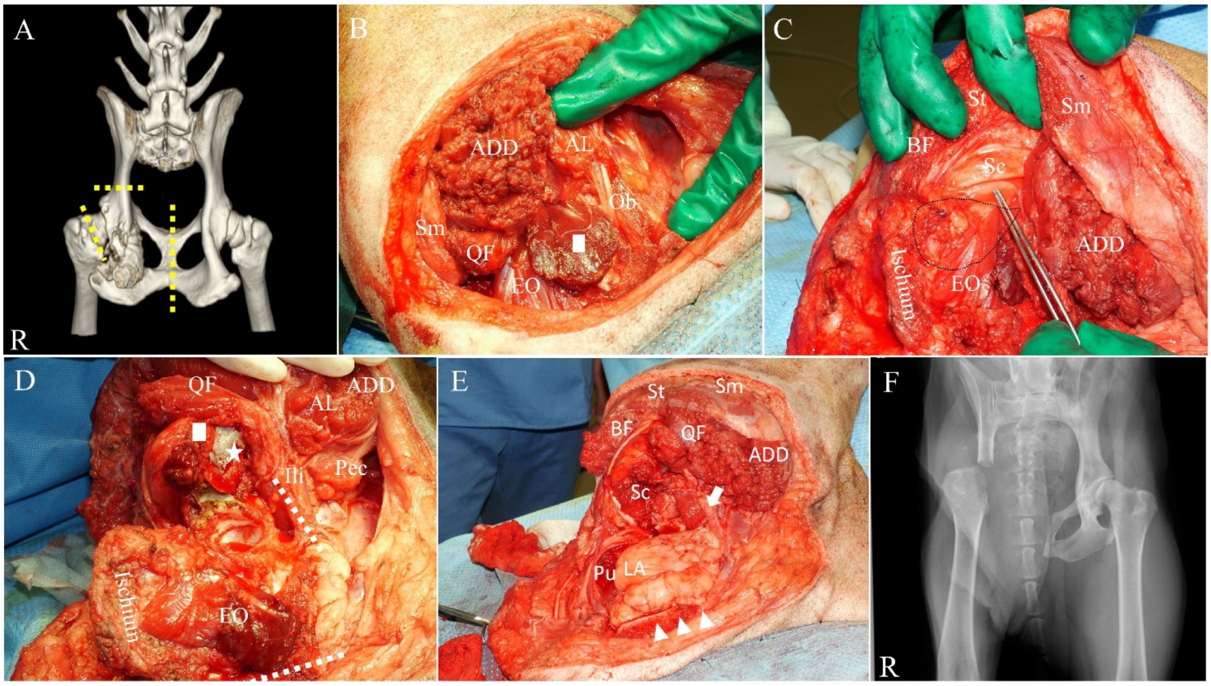

Fig. 1. Diagnostic imaging, surgical plan, intraoperative images, and postoperative radiographic image of the canine patient. (**A**) Dorsal view of the coronal reformatted CT image (bone algorithm). Location of the proposed bone cuts (dotted lines) for mid-to-caudal partial hemipelvectomy. (**B**) Intraoperative photograph of the ventral approach. The dog is positioned in the oblique recumbent position (midway between ventral and left lateral recumbency) with the right leg abducted. The cranial aspect is to the left of the image, and the caudal aspect is to the right. The medial thigh muscles have been partially or completely dissected from their origin and obturator nerve are exposed. The square indicates the resected external obturator muscle. (**C**) Intraoperative photograph of the dorsolateral approach. Lateral and caudal aspect of the right pelvic limb with the patient in left lateral recumbency. The sciatic nerve is exposed. The approximate location of the tumor covered by the soft tissue is indicated by the black dotted line. (D, E) Intraoperative photograph of the ventrocaudal view. The patient is positioned in left lateral recumbency. The right pelvic limb is flexed and rotated externally. The tip of the hind limb is toward the upper right of the image. (**D**) The star indicates the cut end of the femoral neck. Location of the proposed bone cuts (dotted lines) for mid-to-caudal partial hemipelvectomy. The square indicates the trochanteric fossa of the femur. (**E**) Intraoperative photograph after *en bloc* resection. An osteotomy of the ilium is performed just before the acetabulum (arrow). A midline pelvic symphysiotomy is then made (arrowhead). (**F**) Postoperative radiographic image and appearance of the canine patient. Ventrodorsal radiograph of the pelvis of the canine patient on postoperative day 36. Moderate muscle wasting in the right hindlimb is observed. ADD, adductor magnus et brevis muscle (m); AL, adductor longus m; BF, biceps femoris; EO, external obturator m; Gem, gemelli m; Ili, Iliopsoas m; IO, internal obturator m; LA, levator ani m; Ob, obturator nerve; Pec, pectineus m; Pu, pudendal nerve; QF, quadratus femoris m; Sc, sciatic nerve; SG, superficial gluteal; Sm, semimembranosus m; St, semitendinosus m.

Based on the histological diagnosis and the results of the CT scan, a bone tumor was suspected. Since there was no evidence of metastasis, mid-to-caudal partial hemipelvectomy was considered for the purpose of reliable locoregional control. Pelvic osteotomy was planned to be performed at the symphysis pelvis, including a surgical margin of more than 2 cm (Fig. 1A). Although a periosteal reaction was observed on the pelvic aspect of the caudal acetabulum, there was no obvious osteolysis or periosteal reaction on the iliac bone, and therefore osteotomy at the caudal side of the iliac bone, which is the cranial rim of the acetabulum, was planned. The surgical margin for soft tissue was defined as 1 cm or more of muscle or two fasciae. The internal obturator, external obturator, and gemelli muscles were included completely within the surgical margin, while the quadratus femoris, biceps femoris, semimembranosus, and semitendinosus muscles were included partially. Since there was no evidence of tumor invasion into the coxofemoral joint, it was possible to preserve the hindlimb by performing a femoral head and neck osteotomy. Based on one report of a similar procedure for pelvic fracture, postoperative function of hindlimb was predicted to be approximately normal [1]. However, due to the presence of the sciatic nerve adjacent to the tumor, it was decided that if there was a need to include the sciatic nerve in the surgical margin, amputation would be performed.

On day 36, following the consultation with the owners, a mid-to-caudal partial hemipelvectomy and femoral head and neck osteotomy were performed to radically excise the ischial mass and preserve the right hindlimb. The dog was premedicated with atropine sulfate (0.05 mg/kg IM) (Fuso Pharmaceutical, Osaka, Japan), midazolam (0.1 mg/kg IV) (Sandoz, Tokyo, Japan), ketamine hydrochloride (0.5 mg/kg IV) (Fujita Pharma, Tokyo, Japan), and fentanyl (5 µg/kg IV) (Daiichi Sankyo Propharma, Tokyo, Japan). Anesthesia was induced with propofol (6 mg/kg IV) (Mylan, PA, USA) and maintained with sevoflurane (SEVOFLO®, Zoetis JP, Tokyo, Japan) in oxygen delivered via an endotracheal tube. Fentanyl (2 µg/kg/hr continuous rate infusion [CRI]), remifentanil hydrochloride (36 µg/kg/hr CRI) (Daiichi Sankyo Propharma), ketamine hydrochloride (0.6 mg/kg/hr CRI), and meloxicam (0.2 mg/kg SC) (Metacam®, Boehiringer Ingelheim, Ingelheim, Germany) were administered for pain control. A lumbosacral epidural administration of morphine hydrochloride hydrate (0.1 mg/kg) (Shionogi Pharma, Oosaka, Japan) and ropivacaine hydrochloride (0.22 mg/kg) (Anapeine®, Sandoz) were also performed for local anesthesia. Cefazolin sodium hydrate (22 mg/kg IV) (Cefamezinα®, LTL Pharma, Tokyo, Japan) was administered at induction and then every 90 min during anesthesia.

The dog was placed in the oblique recumbent position (midway between ventral and left lateral recumbency). The right hemipelvis and ipsilateral hindlimb were clipped and aseptically prepared from the level of the tarsocrural joint to the level of the contralateral coxofemoral joint using a hanging limb technique. The right hindlimb was abducted, and a skin incision was made along the medial thigh from the inguinal region to the level of the ischial tuberosity (Fig. 1B). The skin was elevated to expose the medial thigh muscles. The gracilis, pectineus, adductor magnus et brevis, and adductor longus muscles were dissected from their origins and retracted distally. The quadratus femoris muscle was incised distal to its origin with a minimum of 1 cm beyond the tumor margin after dissection of the semimembranosus muscle from the ischial tuberosity. To expose the branch of the obturator nerve and medial circumflex femoral artery and vein, a part of the external obturator muscle was transected near its origin and reflected (Fig. 1B). The branch of the obturator nerve was identified and transected. The obturator branches of the medial circumflex femoral artery and vein were isolated and ligated with a monofilament non-absorbable suture, both proximally and distally. Transection of vessels was performed between the two ligatures. The pelvic symphysis was completely exposed using a periosteal elevator to free the remaining soft tissue attachments to allow for osteotomy of the pelvic symphysis. The prepubic tendon and the inguinal ligament were transected from their attachment to the cranial pubis to expose the pecten of the pubic bone and the iliopectineal eminence. The external iliac, femoral, and deep femoral arteries and veins were isolated over the iliopsoas muscle and preserved.

To approach the lateral and caudal aspects of the thigh, the right hindlimb was adducted. A curvilinear incision was made around the limb at the level of the mid femur, such that the incision for the dorsolateral approach began near the level of the cranioventral iliac spine and continued caudally along the lateral aspect of the pelvic limb. This skin incision was connected to the incision on the medial thigh. The semitendinosus and biceps femoris muscles were transected at the sacrotuberous ligament and ischial tuberosity, and the sacrotuberous ligament was incised from the ischial tuberosity. These muscles were retracted cranially until the sciatic nerve and caudal gluteal artery and vein were visible (Fig. 1C). The sciatic nerve and the caudal gluteal artery and vein remained intact because these nerves and blood vessels course over the surface of muscles and were not directly attached to the mass (Fig. 1C, Supplementary Fig. 2A). The pudendal nerve and the internal pudendal artery and vein running on the surface of the internal obturator muscle were also unaffected by the mass and remained intact (Supplementary Fig. 2B). These visualized nerves and blood vessels were retracted with umbilical tape to avoid iatrogenic damage and were preserved.

The right hip joint was flexed and rotated externally to expose the femoral head and neck. The iliopsoas muscle was retracted cranially, and the hip joint capsule was exposed and partially incised. The ligament of the femoral head was cut, and femoral head and neck osteotomy was performed using an oscillating saw (Fig. 1D). The hip joint capsule was completely incised, and the gemelli muscle, the tendon of the external obturator and internal obturator muscles were transected at their insertion on the trochanteric fossa of the femur. To expose the caudal shaft of the ilium, the deep gluteal muscle was elevated subperiosteally from the body of the ilium in a cranial direction. An osteotomy of the ilium was performed just prior to the acetabulum using an oscillating saw (Fig. 1D). A midline pelvic symphysiotomy was then performed (Fig. 1D). The mass and associated bones were freely movable and were lifted ventrally. The coccygeus and levator ani muscles were incised distal to their origin, with a minimum of 1 cm beyond the tumor margins. The mass and associated bones and surrounding muscles were removed *en bloc* (Fig. 1E). A defect in the ventral pelvic canal was closed primarily using the remaining medial thigh muscles. Simultaneously, where it was possible, the medial thigh muscles were attached to the surrounding tissues in their previous direction of action. The adductor longus and pectineus muscles were attached to the prepubic and inguinal ligaments, respectively. Most of the adductor magnus and brevis muscles were re-attached to the contralateral adductor magnus and brevis muscle in the midline with a mattress suture. The quadratus femoris and a part of the adductor magnus and brevis muscles were attached to the remaining levator ani muscle. The biceps femoris, semitendinosus, and semimembranosus muscles were attached to the surrounding soft tissues in their previous direction of action. A negative suction drain was placed, and the subcutaneous tissues and skin were closed. It took 372 min to do this operation.

The histological examination of the ischial lesion revealed that majority of the tissue showed a hypocellular area proliferated by spindle-shaped cells with dense collagen fibers (Supplementary Fig. 3). Nuclear atypia of the spindle-shaped cells was mild. A part of the tissue exhibited a relatively hypercellular area containing a proliferation of atypical spindle-shaped cells with enlarged nuclei. Reactive bone formation, but not neoplastic osteoid formation, was observed. There was no production of neoplastic cartilage matrix. The degree of differentiation was high, and the mitotic index was low (<1 index per 10 400× power fields). The final diagnosis was sarcoma of unknown origin but excluded osteosarcoma and chondrosarcoma. Tumor-free margins were seen at the cut edge of the bone and the outer edge of soft tissues. There was no evidence of tumor invasion in the hip joint.

The dog recovered uneventfully from anesthesia, and fentanyl (2 µg/kg/hr CRI), ketamine hydrochloride (0.12 mg/kg/hr CRI) and meloxicam (0.2 mg/kg SC q24 hr) were administered for postoperative pain management. Cefazolin sodium hydrate (20 mg/kg IV q8 hr) was administered as an antibacterial agent. Fentanyl and ketamine were discontinued after 48 hr. The dog was unable to stand or walk independently immediately after surgery. Forty-eight hours after surgery (postoperative day 2), the dog was comfortable, with moderate edema on the right hindlimb and was ambulatory for short distances without weight-bearing of the right hindlimb. From 48 hr until discharge, buprenorphine hydrochloride (0.02 mg/kg IM q8 hr–12 hr) (Nissin Pharma, Yamagata, Japan) and meloxicam (0.2 mg/kg SC q24 hr) were administered for analgesia. By postoperative day 7, there was no serous or sanguineous drainage and the drainage tube was removed. The dog was discharged on postoperative day 14. At the time of discharge, the skin incisions had healed. The dog had regained slight weight-bearing ability on the right hindlimb during standing. The dog was able to walk slowly with brief intermittent weight-bearing on the right hindlimb, shortened stride length, and intermittent scuffing. Flexion of the right stifle was minimal, and frequent outward stepping of the hindlimb when walking on slippery surfaces was observed. The dog preferentially lifted the hindlimb at a faster walking pace. The dog was re-examined on postoperative day 36. The dog had partial weight-bearing on the right hindlimb during standing. Right hindlimb placement and use were adequate during slow walk. The stride length and flexion of the right stifle became normal and scuffing almost disappeared. However, lateral rotation of the right hip was noted, and outward stepping of the hindlimb persisted. The dog had moderate muscle wasting in the right hindlimb, most prominently in the semitendinosus, semimembranosus, and biceps femoris muscles (Fig. 1F). At the 6-month postoperative review, the dog had almost complete weight-bearing when standing and a normal gait when walking but tended to "bunny hop" when running. There was no outward stepping of the hindlimb, and muscle atrophy was mostly resolved. However, lateral rotation of the right hip continued. No orthopedic or neurologic abnormalities, which are rarely seen after hindlimb amputation, were observed. Thoracic and abdominal radiographs revealed no evidence of local recurrence or metastasis.

The referring veterinarian reported by telephone that the dog was doing well at home and had satisfactory use of the right hindlimb after the 6-month postoperative follow-up. There was no sign of local recurrence or sarcoma metastasis. The dog died 821 days after surgery, from a cause unrelated to sarcoma. The dog was able to walk, run, and climb stairs with adequate right hindlimb use until death. The owners were pleased with the dog's hindlimb function and outcomes.

This case report describes a successful oncological outcome and preservation of the ipsilateral hindlimb following mid-to-caudal partial hemipelvectomy and femoral head and neck osteotomy in a large dog. To the best of our knowledge, this is the first report of mid-to-caudal partial hemipelvectomy with hindlimb preservation in a tumor-bearing large dog. This procedure may be an excellent surgical option for dogs with tumors extending cranially beyond the ischium, necessitating the excision of the acetabulum and allowing curative-intent surgery without amputation.

Hindlimb-preserving partial hemipelvectomy has been reported as a salvage treatment for malunion after pelvic fractures in three large dogs [1]. Pelvic osteotomy was performed through the body of the ilium approximately at the level of the lesser ischial notch and just medial to the iliopubic eminence in conjunction with femoral head and neck osteotomy. The only muscles that were transected or dissected free from the bone were the deep gluteal and gemelli internal obturator muscles. Approximately 2 weeks after surgery, the dog started bearing weight on the operated hindlimb and then recovered to an almost normal gait. In the present case, mid-to-caudal partial hemipelvectomy including more extensive resection of the pubis and ischium was performed, and although most of the muscles around the hip joint attached to these bones were transected and could not be reattached to their origin, an almost normal gait was possible.

The gluteal muscles, along with the biceps femoris, semitendinosus, and semimembranosus muscles, form a large group of muscles that stabilizes the femoral head into the acetabulum during weight-bearing [9] and these muscles play an important role in hip extension [5]. Of these muscles, only the superficial and middle gluteal muscles were fully preserved and could be important for hip stability and extension under weight-bearing in the hip joint with no bone-on-bone contact. Stifle flexion is also the primary function of the biceps femoris, semitendinosus, and semimembranosus muscles [5]. These muscles cannot be reattached to their origin, but are anchored to the surrounding soft tissues in their previous direction of action. A previous report of ischiectomy with limb preservation suggested that anchoring may provide a scaffold for the creation of a firm, fibrous adhesion at these sites, resulting in the maintenance of the range of motion of the biceps femoris, semitendinosus, and semimembranosus muscles [7]. As stifle flexion in this case temporarily decreased after surgery, but recovered, these muscles would have regained their function and consequently contributed to hip stability, hip extension, and stifle flexion. The sciatic nerve is also important for the movement of these muscles. Although preservation of the sciatic nerve was possible in this case, walking on the dorsum of the paw has been reported in dogs with sciatic nerve injury after hindlimb-preserving partial hemipelvectomy [1]. Therefore, preserving the function of the gluteal and hamstring muscles and sciatic nerve could be essential to maintaining the function of the hindlimb postoperatively. If these muscles and the sciatic nerve cannot be preserved due to the infiltration of the ischiatic tumor, mid-to-caudal partial hemipelvectomy with hindlimb preservation becomes difficult, and mid-to-caudal partial hemipelvectomy combined with amputation should be considered owing to permanent functional impairment of the affected hindlimb.

There is limited research on obturator nerve resection and hindlimb preservation in humans and dogs. Circumduction and wide-based gait caused by abnormal abduction during ambulation have been reported in dogs and humans with obturator neuropathy [4, 11]. A dog with bilateral obturator neuropathy showed instability in standing up and walking on a slippery surface [11]. In this case, frequent outward stepping of the hindlimb when walking on slippery surfaces and wide-based gait were observed after surgery. These clinical signs could result from obturator nerve transection. However, the long-term postoperative course showed satisfactory use of the hindlimb. Therefore, the effect of obturator nerve transection after this procedure, if unilateral, could be minimal in dogs.

In the present case, the selection of margins was challenging because a definitive histologic diagnosis was not available. The preoperative histologic diagnosis was sarcoma of unknown origin, which includes osteosarcoma and/or chondrosarcoma. Reports of bone tumors occurring in the ischium are extremely rare [3]; details regarding the surgical technique and setting of the surgical margin are unknown. In a report of a dog with grade 1 chondrosarcoma that underwent ischiectomy, a surgical margin of 1 cm was selected based on the discrete nature of the tumor with a lack of medullary extension or periosteal reaction on CT [7]. Previous recommendations for surgical margins for pelvic osteosarcoma in dogs have often been >2 cm of normal tissue [10]. In this case, the surgical margin of the bone was defined as at least 2 cm, and that of the soft tissue was defined as 1 cm or more muscle or two fasciae. Consequently, clear resection margins were obtained. Therefore, although further detailed study is needed, this strategy may be recommended for sarcoma of unknown origin arising in the pelvic bone. There was no evidence of tumor invasion into the hip joint. Tumor invasion into the coxofemoral joint, into the femoral head, or into the periarticular soft tissues could make the hindlimb-preserving partial hemipelvectomy difficult. In cases of coxofemoral degenerative joint disease, it is more difficult to evaluate the invasion of the tumor into the coxofemoral joint. Therefore, mid-to-caudal partial hemipelvectomy, concurrent with femoral head and neck osteotomy, could allow curative-intent surgery without amputation for dogs with ischial tumors. However, the decision to preserve the hindlimb should be based on careful consideration of the biological characteristics of the tumor and the extent of tumor invasion of the coxofemoral joint.

The histological diagnosis of this case was sarcoma, and its origin was unknown. Osteosarcoma and chondrosarcoma are the most common malignant tumors that occur in the pelvic bones of dogs. In this case, osteosarcoma and chondrosarcoma were excluded from the final histological diagnosis because there was no production of neoplastic osteoid and cartilage matrix. In humans, tumors with histological findings similar to the present case include myofibroblastic sarcoma, leiomyosarcoma, low-grade fibrosarcoma, desmoplastic fibroma and inflammatory myofibroblastic tumor [8]. Immunostaining with myogenic markers (desmin, smooth muscle actin, muscle actin) is necessary to differentiate between these tumors. Furthermore, these tumors are not reported in detail in dogs. Therefore, further investigation such as immunostaining using specific markers is necessary to determine the true nature of the tumor and make an accurate diagnosis.

This clinical case demonstrates the possibility of successful removal of the caudal pelvic bone, including the acetabulum and femoral head, while preserving good long-term limb function. There have been no previous reports of mid-to-caudal partial hemipelvectomy and femoral head and neck osteotomy in tumor-bearing dogs. Based on this experience, a limb-sparing procedure can be considered in future cases requiring excision of the caudal pelvic bone, including the acetabulum, in tumor-bearing dogs.

CONFLICT OF INTEREST. The authors report no financial or other conflicts of interest related to this report.

ACKNOWLEDGMENTS. The authors acknowledge Dr. Kazuya Matsuda and Dr. Minoru Okamoto for their assistance with the histopathological diagnosis.

REFERENCES

1. Alexander, J. W. and Carb, A. V. 1979. Subtotal hemipelvectomy in the dog. *J. Vet. Orthop.* **1**: 9–14.
2. Bray, J. P. 2014. Hemipelvectomy: modified surgical technique and clinical experiences from a retrospective study. *Vet. Surg.* **43**: 19–26. [Medline] [CrossRef]
3. Bray, J. P., Worley, D. R., Henderson, R. A., Boston, S. E., Mathews, K. G., Romanelli, G., Bacon, N. J., Liptak, J. M. and Scase, T. J. 2014. Hemipelvectomy: outcome in 84 dogs and 16 cats. A veterinary society of surgical oncology retrospective study. *Vet. Surg.* **43**: 27–37. [Medline] [CrossRef]
4. Busis, N. A. 1999. Femoral and obturator neuropathies. *Neurol. Clin.* **17**: 633–653, vii. [Medline] [CrossRef]
5. Hermanson, J. W. 2013. The muscular system. pp. 185–280. In: Miller's Anatomy of the Dog, 4th ed. (Evans, H. E. and Lahunta, A. D. eds.), Elsevier, St. Louis.
6. Kramer, A., Walsh, P. J. and Seguin, B. 2008. Hemipelvectomy in dogs and cats: technique overview, variations, and description. *Vet. Surg.* **37**: 413–419. [Medline] [CrossRef]
7. Oblak, M. L. and Boston, S. E. 2015. Ischiectomy with limb preservation for a dog with ischial chondrosarcoma: case report and surgical technique. *Vet. Surg.* **44**: 571–575. [Medline] [CrossRef]
8. Saito, T., Mitomi, H., Kurisaki, A., Torigoe, T., Takagi, T., Suehara, Y., Okubo, T., Kaneko, K. and Yao, T. 2013. Low-grade myofibroblastic sarcoma of the distal femur. *Int. J. Surg. Case Rep.* **4**: 195–199. [Medline] [CrossRef]
9. Smith, G. K., Karbe, G. T., Agnello, K. A. and McDonald-Lynch, M. B. 2018. Pathogenesis, diagnosis, and control of canine hip dysplasia. pp. 824–848. In: Veterinary Surgery: Small Animal, 2nd ed. (Tobias, K. M. and Jonston, S. A. eds.), Elsevier, St. Louis.
10. Straw, R. C., Withrow, S. J. and Powers, B. E. 1992. Partial or total hemipelvectomy in the management of sarcomas in nine dogs and two cats. *Vet. Surg.* **21**: 183–188. [Medline] [CrossRef]
11. Vanhaesebrouck, A. E., Maes, S., Van Soens, I., Baeumlin, Y., Saey, V. and Van Ham, L. M. 2012. Bilateral obturator neuropathy caused by an intrapelvic fibrosarcoma with myofibroblastic features in a dog. *J. Small Anim. Pract.* **53**: 423–427. [Medline] [CrossRef]