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NOTE

Surgery

Management of sternal dislocation with and without surgery in cats: Owner-assessed long-term follow-up of two clinical cases

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ABSTRACT. The aim of this paper is to report two cases of sternal dislocation (SD) in cats and the long-term outcomes with and without surgery. In a cat with poly-traumatized SD (Case 1), mandibular, radial, and ulnar fractures were corrected first, and the SD was allowed to heal without intervention for 14 months. However, normal healing did not occur and sternal instability remained. Therefore, the SD was corrected surgically, and the cat recovered fully within 4 weeks. In a cat with isolated SD (Case 2), surgery was performed, and normal posture and gait were regained after 5 weeks. Furthermore, in both cases, no postoperative complications were observed during follow-up. Therefore, surgical correction of SD in cats is recommended.

KEY WORDS: cat, sternal dislocation, surgical management

The sternum stabilizes the thoracic cavity by attaching to the ribs by cartilage, and it plays a pivotal role in protecting vital organs, such as the heart and lungs, as well as major blood vessels of the chest from injury and all quadrupeds animals lie down on the sternum. It is the largest and longest flat bone of the body and consists of the manubrium, the body, and the xiphoid process in human [7] and in feline anatomy, the sternum consists of 8 sternebrae (the manubrium, a body with 6 sternebrae, and the xiphoid). Numerous references in the literature focus on sternal fracture in human medicine, as either isolated or poly-traumatized forms [3, 10, 14, 19]. Several reports have also presented cases of sternal loss in humans due to traffic accidents [2, 18].

The large amount of literature on sternal dislocation (SD) in human medicine indicates the importance of sternal fracture in human medicine and trauma surgery [2, 18]. However, management of sternal fracture in veterinary practice remains beyond the normal scope of veterinary trauma surgeons, as reflected by the small number of reports in the veterinary field. Only one peer-reviewed study in a dog [15] and one anecdotal study of dogs and cats [9] are available. To the best of our knowledge, this is the first report of sternal fracture in cats. Furthermore, we believe this is the first report of surgical management using locking plates (LP) for cases of an isolated SD and a poly-traumatized SD in veterinary practice. Long-term follow-up is also provided.

Case 1: A 27-month-old spayed female domestic cat (4.85 kg) was presented to the Royal Animal Medical Center. The cat was severely weak and unable to stand following a two-story fall. Dyspnea (56 breath/min) was present, but tachycardia was not (heart rate, 168 beat/min). Radiographs revealed fractures of the mandible, radius, and ulna, as well as SD between the 6th and 7th sternebrae (Figs. 1B, 1D and 3). The surgical team decided to first correct the mandibular, radial, and ulnar fractures using standard techniques. Clinical signs were observed carefully, and at the request of the owner, surgery of the SD was not pursued.

The cat remained in the hospital for 14 months and 19 days to allow for healing of the radial, ulnar, and mandibular fractures and to monitor the SD via radiographs taken at 2-month intervals. The cat ate well after surgery; however, normal gait and posture were not achieved even though the radial, ulnar, and mandibular fractures healed. Computed tomography (CT) scan images also confirmed the radiographic findings (Fig. 2). Thoracic instability was detected on manual palpation, and a depression was visible at the area of the SD when the cat was positioned dorsoventrally.

We then performed surgery to correct the SD as described below. Before and during surgery, intravenous (IV) fluid therapy with 0.9% normal saline at 10 ml//kg/hr (CJ HealthCare, Eumseong-gun, Chungcheongbuk-do, South Korea) was administered to treat dehydration and to prevent hypovolemic shock [17]. Fluid therapy was continued for 4 days postoperatively at a maintenance

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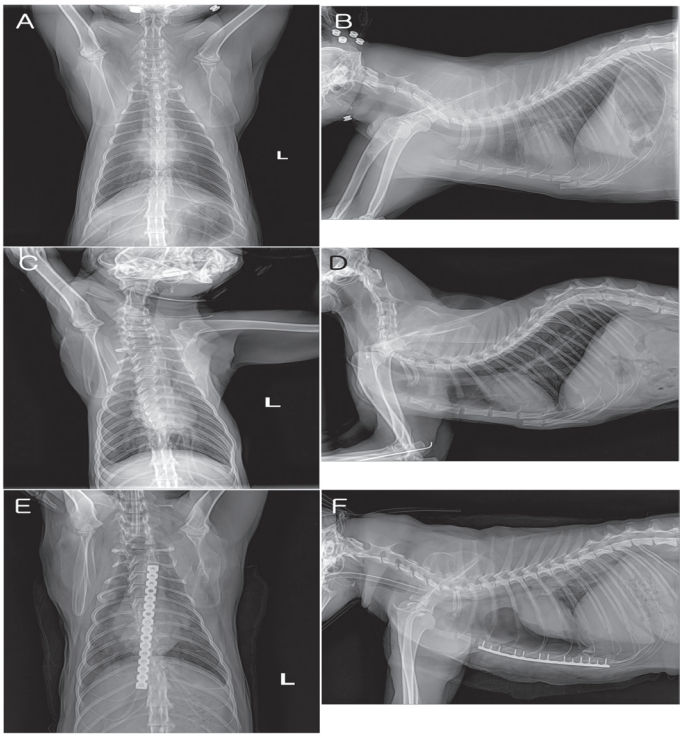

Fig. 1. Preoperative and postoperative radiographs of Case 1, (A–B) Following surgical correction of the mandibular, radial, and tibial fractures, the sternal dislocation (SD) remains uncorrected. (C–D) Preoperative radiographs 14 months after the initial trauma demonstrate that the SD is not united, and the thoracic cavity is abnormally shaped. (E–F) Immediate postoperative radiographs show the plate and screw fixation as well as the SD correction. (F) Postoperative pneumothorax was identified.

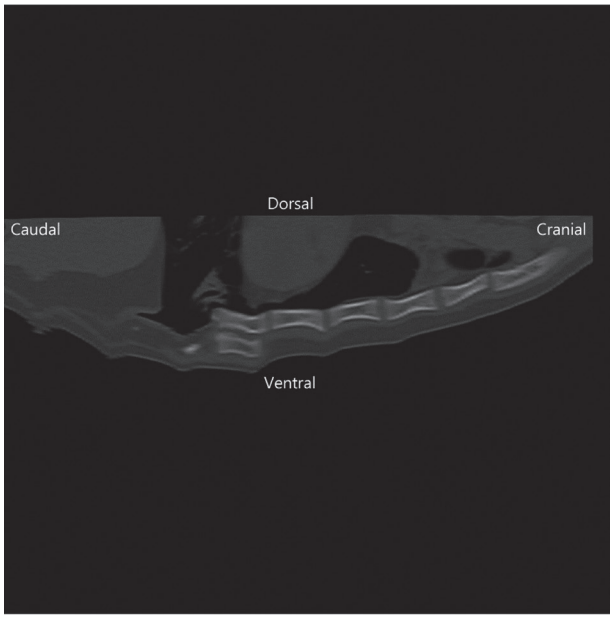

Fig. 2. Computed tomography image of Case 1. The computed tomography image also confirms non-union of the SD.

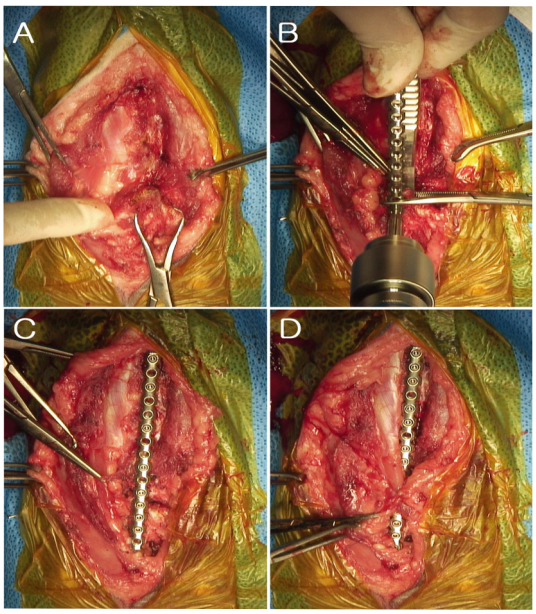

Fig. 3. Intraoperative images of Case 1. (A) Nonunion of the SD and fibrosis. Lack of sternal stability was also present. (B) Fixation of the distal part of the sternum. (C) Fixation of the 16-hole plate. (D) Closure of the incision.

rate (45–54 m*l*/kg/day). Hematology, serum biochemistry, electrocardiography (ECG), and blood pressure were obtained pre- and postoperatively.

Case 2: A 96-month-old neuter male domestic cat (5.27 kg) was presented to the clinic in respiratory distress. The owner revealed that the cat was sensitive to the sound of the vacuum cleaner, and when the owner started cleaning, the cat jumped on the furniture, fell down, and then displayed altered behavior. On presentation, the cat exhibited dyspnea (54 breath/min), tachycardia (225 beat/min), discomfort, and swelling of the ventral thorax. SD was suspected since abnormal movement of the sternum was visible, and instability was palpated. SD between the 4th and 5th sternebrae was confirmed on radiographs (Fig. 4). Surgical repair of the SD was performed as described below. At 3 weeks post-surgery, the cat had not regained normal gait or posture; however, at 5 weeks post-surgery the cat had recovered and displayed normal cardiovascular parameters (including heart rate, rhythm and pulse quality) and respiratory rate. Telephone follow-up with the owner 19 months following the surgery revealed no abnormalities related to this incident.

In preparation for surgery, both cats were administered intravenous (IV) 0.9% normal saline (10 m*l*/kg/hr, CJ HealthCare, Eumseong-gun, Chungcheongbuk-do, South Korea), cephradine (30 mg/kg IV, bid; Panzedin Inj®., Hankook Korus Pharm. Co., Ltd., South Korea) and tramadol (2 mg/kg IV, tid, Maritrol Inj®., Jeil Pharmaceutical Co., Ltd., South Korea). General anesthesia was then induced with IV propofol (6–8 mg/kg, Provive®1%, Myungmoon Pharm. Co., Ltd., Seoul, Korea), the patient was intubated, and sevoflurane (1–5%; Abbott Korea Ltd., Seoul, Korea) was used to maintain anesthesia. Oxygen level and positive pressure were maintained, and ECG and CO_2 partial pressure were monitored by an automated anesthetic machine (Paieon,

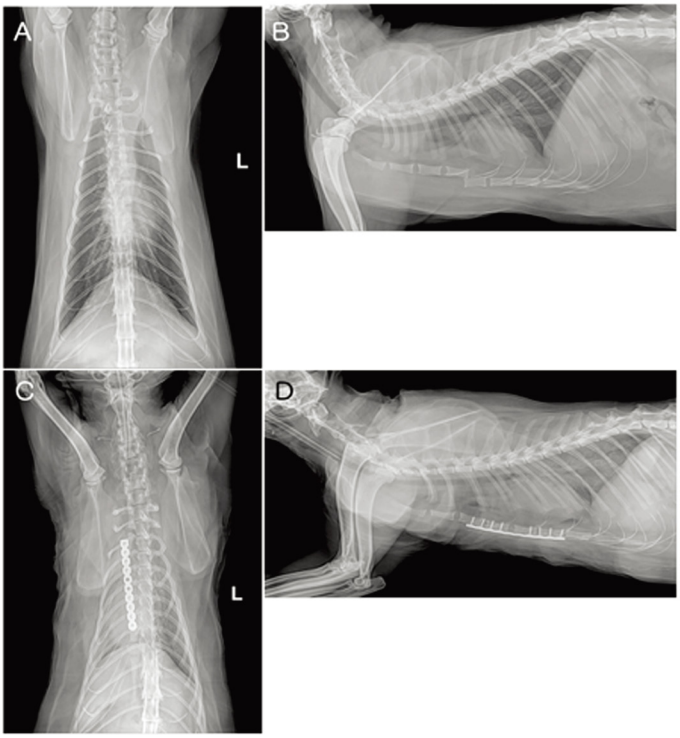

Fig. 4. Preoperative and postoperative radiographs of Case 2. (A–B) Preoperative radiographs illustrating the SD along with soft tissue density and swelling of the subcutaneous tissue. (C–D) Immediate postoperative radiographs show the plate and screw fixation as well as SD correction.

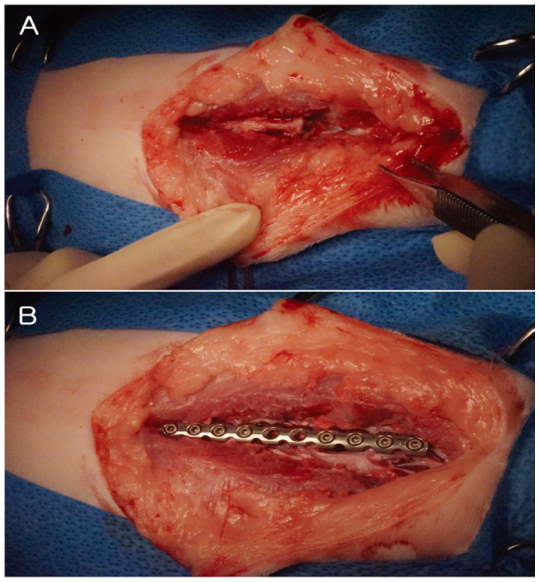

Fig. 5. Intraoperative images of Case 2. (A) Sternal dislocation. (B) Fixation of the 10-hole plate.

J&TEC, Goyang-Si, Gyeonggi-do, South Korea) during surgery.

After shaving the entire affected sternal region, aseptic preparation and draping were performed, and the animal was positioned in dorsal recumbency. A midline longitudinal incision was made in the skin on the ventral aspect of the sternum, and the subcutaneous tissue was dissected to expose the dislocated sternal joint.

In Case 1, the fibrotic tissue and muscle were dissected, and the exposed ends of the affected sternebrae were scraped with the scalpel to expose fresh tissue in order to facilitate the healing process. The dislocation was then reduced using traumatic reduction forceps (Fig. 3) and stabilized and fixed with a compression LP and locking screws, taking care to avoid injury to the pleura or internal organs. In Case 2, after exposing the dislocated sternal joint, the ends were a positioned using traumatic reduction forceps. Since the wound was acute, scraping with a scalpel was not performed (Fig. 5).

The length and size of the plate and screws and the number of screws used were chosen and contoured based on the radiographs taken before surgery and considering the anatomic differences of the animal, position of the dislocation, and the thickness of tissue present to maintain adequate stability. The length of the plate was 120.72 mm with 16 holes and fixed with 13 screws (3 screws were 6 mm and 10 screws were 8 mm in length) for Case 1 (Figs. 1 and 3) and 77.06 mm with 10 holes and fixed with 8 screws (all were 8 mm in length) for Case 2 (Figs. 4 and 5). The width and thickness of the plates for both cats were 7 mm and 2.58 mm, respectively, and screw diameters were 1.5 mm. The plates and screws were purchased from BS.COREM (Wanju-gun, Jeollabuk-do, South Korea). The incision was then closed routinely and postoperative radiographs obtained to confirm successful alignment. Postoperative pneumothorax was corrected by thoracentesis using the following technique as previously described [4]. After shaving and aseptically preparing the area of 7th and 8th intercostal space near the costochondral junction, a 19-gauge Echotip needle (Wilson-Cook, Winston-Salem, NC, U.S.A.) with an attached thoracic drain was carefully inserted into the pleural space using fluoroscopy guidance (OEC® 9800 Plus, GE OEC Medical System, Inc., Salt Lake City, UT, U.S.A.). The air was aspirated, and the needle was then removed.

The cats were kept in the intensive care unit (ICU) for 4 days after surgery for monitoring of vital signs and administration of analgesics and fluid therapy. Atropine (0.05 mg/kg, IV, p.r.n., Atropine Inj., Jeil Pharmaceutical Co., Ltd.), enrofloxacin (10 mg/kg IM, sid; Enrobac Inj®, CTC Bio, South Korea), cephradine (30 mg/kg IV, bid), and tramadol (2–3 mg/kg IV, bid or tid) were administered. A gastrointestinal protective agent (cimetidine 10 mg/kg IV, bid; Cimetidine Inj®., Dongkwang Pharm Co., Ltd., Seoul, South Korea) was also administered postoperatively.

The cat in Case 1 was released 28 days after surgery, and the cat in Case 2 was released at 35 days, fully recovered. The referring veterinarians conducted long-term follow-up for postoperative complications, morbidity, and recurrence of signs via

Table 1. Pre- and postoperative clinical parameters of the cats with sternal dislocation that underwent surgery

Clinical parameters	Reference range	Case 1			Case 2		
		Day 0	Day 7	Day 28	Day 0	Day 7	Day 35
RR (breath/min)	20–30	56	35	32	54	34	30
Heart rate (beat/min)	140–200	168	173	178	225	188	182
pH	7.21–7.41	7.29	7.38	7.25	7.35	7.24	7.24
pCO_2 (mmHg)	28–50	39.4	39.8	40.2	33	34.1	40.1
pO_2 (mmHg)	24–48	73	52	71	43	61	74.2
Na^+	148–157	161 (H)	159 (H)	155	157	157	148
K^+	3.3–4.5	4.6	4.7 (H)	4.3	3.3	4	3.7
Cl^-	117–127	123	120	125	116	118	113
Ca^{2+}	1.11–1.38	1.4	1.37	1.34	1.29	1.3	1.24
HCO_3^-	21–28	18.2	22.7	20.1	17.9	14	21
cBase (B)	−2–3	−7.4	−1.4	−6.3	−6.3	−12.2	−13.2
cBASE (B, ox)	−2–3	−7.6	−1.8	−7.5	−6.8	−12.5	−10.2
Angap (mmol/*l*)	7–16	22.8	16.3	9.9	23.1	25.0	14.0
Osm (mOsm/*l*)	290–330	325	321	310	312	320	296
Lactate (mmol/*l*)	0–2.7	5.2 (H)	3.8	2.8	4.2 (H)	2.4	2.5
Hct (%)	24–55	34.4	32.6	35.2	34.9	36.4	37.2
Hb (g/d*l*)	8–15	11.8	11.4	12.1	11.5	13	13.2
RBC $\times 10^6/\mu l$)	5–11	8.36	8.21	7.41	6.4	7.1	7.5
WBC ($\times 10^3/\mu l$)	5.5–19.5	35.09 (H)	8.11	10.2	21.48 (H)	20.4	14.2
Neutrophil ($\times 10^3/\mu l$)	2.5–12.8	28.67	23.67	11.2	20.14 (H)	16.96	10.23
Monocyte ($\times 10^3/\mu l$)	0.2–2	1.06	0.91	0.62	0.54	0.54	0.31
PLT ($\times 10^3/\mu l$)	150–500	599	667	281	326	273	272
MPV (f*l*)	5–20	10.4	10.8	11.3	17.3	17.6	17.1
CK (U/*l*)	49–688	721 (H)	692 (H)	651 (H)	4,032 (H)	1,002 (H)	701 (H)
ALT (U/*l*)	12–130	25	9	15	138	102	108
ALP (U/*l*)	14–111	31	29	35	44	21	31
AST (U/*l*)	6–44	32	19	25	105 (H)	144 (H)	64 (H)
cTnI (*n*g/m*l*)	0–0.09	0.06	-	-	1.06 (H)	0.23	0.09
TP (mg/d*l*)	5.7–8.9	7.4	8.4	8.2	6.7	7.4	7.2
Albumin (mg/d*l*)	2.2–4	2.6	2.8	3.1	2.9	2.8	3.1
BUN (mg/d*l*)	16–36	17.5	31.2	15.2	11	30.8	13
CRE (mg/d*l*)	0.8–2.4	1.4	1.3	1.1	1.9	1.6	0.9
Glucose (mg/d*l*)	74–159	117	176 (H)	144	131	137	135

RR, respiratory rate; pCO_2, partial pressure of carbon dioxide; pO_2, partial pressure of oxygen; Hct, hematocrit; Hb, hemoglobin; RBC, red blood cell; WBC, white blood cell; PLT, platelets; MPV, mean platelet volume; Angap, anionic gap; Osm, osmolality; CRE, creatinine; BUN, blood urea nitrogen; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALP, alkaline phosphatase; CK, creatinine kinase; cTnI, cardiac troponin-I; TP, total protein; H, higher than reference level. In the first case, the data presented here include pre- and post-SD correction.

recorded telephone contact using a medical questionnaire.

Laboratory tests (hematology, serum biochemistry) and patient information (breed, age, sex, and body weight) from the medical records are presented in Table 1. EDTA samples were analyzed using ADVIA 2120i™ (Siemens Healthcare Diagnostics, Vienna, Austria) for hematology, and blood gas, electrolytes, and lactate were analyzed using an ABL80 FLEX BASIC blood gas analyzer (Radiometer Medical, Brønshøj, Denmark). Blood anionic gap and osmolality were measured as described previously [13]. Blood was centrifuged at 3,000 rpm and plasma biochemistry was measured using a Hitachi 7180 instrument (Hitachi, Tokyo, Japan). Blood cardiac troponin (cTnI) was analyzed on the i-STAT®1 stall-side analyzer (Abbott, Kyoto, Japan) according to manufacturer instructions. Radiographs were obtained using Titan 2000, (COMED Medical Systems Co., Ltd., Seoul, Korea) and interpreted by an experienced (10 years) radiologist for both animals. CT imaging was performed using an ECLOS 16-row detector CT scanner (Hitachi) to exclude other pathological abnormalities. Respiratory rate was recorded by the movement of the abdominal and chest wall (breath/min). ECG was performed with a Cardiofax ECG-9020 electrocardiograph (Nihon Kohden, Tokyo, Japan), and heart rate was recorded.

To the best of our knowledge, this is the first report on the clinical findings, diagnosis, and treatment of isolated and poly-traumatized SD in cats that also evaluated the short- and long-term outcomes with and without surgical management. Furthermore, this is the first report on the use of a LP for SD fixation in veterinary medicine. Even though cardiac and respiratory parameters were normal in the poly-traumatized cat, after 14 months the cat still displayed gait abnormalities and recovered smoothly after the surgical procedure. The isolated SD in the second case was corrected by surgery, and the cat recovered within 5 weeks.

Generally, conservative treatments for SD in humans are suggested [1]. The most common complication after an injury in

Table 2. Questionnaire for owners regarding long-term outcomes of sternal dislocation surgery in the cats

1	What was the condition of eating?		
	■ Normal	■ Decreased	■ Increased
2	What was the condition of drinking water?		
	■ Normal	■ Decreased	■ Increased
3	Did you observe any weakness/ lethargy/depression?		
	■ Yes	■ No	
4	Did the cat move comfortably with all four legs?		
	■ Yes	■ No	
5	Did the cat spend time lying down on its chest?		
	■ Yes	■ No	
6	Did you observe hyper-excitability or abnormal movements?		
	■ Yes	■ No	
7	Did you hear any abnormal sounds or vocalizing?		
	■ Yes	■ No	
8	What was the respiratory rate?		
	■ Normal	■ Decreased	■ Increased
9	What was the body temperature?		
	■ Normal	■ Decreased	■ Increased
10	What was the condition of the feces?		
	■ Normal	■ Constipation	■ Loose or Diarrhea
11	How many times has the pet urinated or defecated today?		
	■ One time	■ Two times	■ 3 or more

patients with isolated sternal fractures is pain, and up to two-thirds of patients are managed with analgesia alone. Surgery is only suggested in human trauma medicine when there is marked displacement, uncontrolled pain, cardiorespiratory disturbances, or clinical non-union [11]. In Case 2, there were significant alterations in cardiac (heart rate was 225 beat/min and ST interval was elevated transiently) and respiratory parameters (respiratory rate was 54 breath/min); therefore, open reduction and lock and screw plate fixation was performed.

No major complications occurred in the first case; the cat had abnormalities in gait for 3 weeks and recovered completely by 4 weeks, as evidenced by radiographs, normal gait, and normal hematology and serum biochemistry results. The clinical signs of SD in humans are associated with type of injury, position, and degree of displacement [8]. The second case in this study had associated signs of dyspnea, tachycardia and thoracic pain/discomfort.

Several fixation techniques are applicable in human medicine, such as stainless-steel wires, Steinmann pins and wire, dynamic compression plates (DCP), sternal lock plates, T-shaped compression-tension stainless steel plates and screws, titanium mandibular plates, cervical plates, and titanium LPs [5]. In one reported canine case, a SD was stabilized using a DCP [13]. In the current report, the appropriate length of LP was contoured and fixed (Figs. 1 and 3–5) carefully by evaluating the tissue and anatomic location, and was matched with the appropriate number and length of screws to induce maximum stability. Sternal function in cats is important as they lie down on the sternum, so appropriate contouring is important. LP may provide better countering in cats than DCP. Furthermore, LP technology protects against plate-screw strain, which is beneficial in cancellous bone [5].

Complications occur in 16% of human patients due to intraoperative errors during implant fixation, including the use of the wrong size plate, screws that are too short, and those that do not have adequate spanning segments (empty screw holes) over the fracture site [16]. We were conscious of this and carefully evaluated the length and thickness of the sternebrae on the radiographic images in order to select the correct size of implant and screws (6–10 mm). Post-operative radiographs confirmed the appropriate positioning of the plate and screws.

The success of orthopedic surgery also depends on the skill of the surgeon [12]. Therefore, the surgeries were performed by same surgeon, Dr. In-Seong Jeong. Long term follow-up radiographs were not obtained in either cat, so union could not be evaluated. However, pathology-related alterations in the hematology and serum biochemistry results (Table 1) returned to normal levels or near normal levels, and normal posture behavior was observed. The cats were considered to have recovered normally, and the owners reported no long-term complications on the questionnaire regarding appetite, gait and posture, temperament, respiratory rate, body temperature, defecation, and urination (Table 2). The limitation of this report is the lack of follow-up radiographs, due to unwillingness of the owners.

The most common cause of sternal fractures and dislocation in humans is blunt anterior chest trauma in traffic accidents (67%), although there are many case reports available related to other traumatic and spontaneous events [6]. Falling may be a common cause of SD in cats, as the SD in both of these cases resulted from a fall. Similar findings were also reported in a dog by Serra *et al* [15]; however, the limitations of these small studies indicate that these findings should be interpreted cautiously.

In conclusion, surgical repair of feline SD had excellent clinical outcomes in these two cases; therefore, surgical correction of SD in cats is recommended.

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REFERENCES

1. Athanassiadi, K., Gerazounis, M., Moustardas, M. and Metaxas, E. 2002. Sternal fractures: retrospective analysis of 100 cases. *World J. Surg.* **26**: 1243–1246. [Medline] [CrossRef]
2. Brookes, J. G., Dunn, R. J. and Rogers, I. R. 1993. Sternal fractures: a retrospective analysis of 272 cases. *J. Trauma* **35**: 46–54. [Medline] [CrossRef]
3. Byun, C. S., Park, I. H., Hwang, W. J., Lee, Y. and Cho, H. M. 2016. Analysis of sternal fixation results according to plate type in sternal fracture. *Korean J. Thorac. Cardiovasc. Surg.* **49**: 361–365. [Medline] [CrossRef]
4. Fossum, T. ed. 2013. Small Animal Surgerym, 4th ed., Mosby, St. Louis.
5. Harston, A. and Roberts, C. 2011. Fixation of sternal fractures: a systematic review. *J. Trauma* **71**: 1875–1879. [Medline]
6. Heyes, F. L. and Vincent, R. 1993. Sternal fracture: what investigations are indicated? *Injury* **24**: 113–115. [Medline] [CrossRef]
7. Hudson, L. C. and Hamilton, B. A. 1993. Musculoskeletal system. pp. 23–31. *In*: Atlas of Feline Anatomy for Veterinarians ed 1 (Hudson, L. C. and Hamilton. B. A. eds.), Saunders, Philadelphia.
8. Khoriati, A. A., Rajakulasingam, R. and Shah, R. 2013. Sternal fractures and their management. *J. Emerg. Trauma Shock* **6**: 113–116. [Medline] [CrossRef]
9. Newton, C. D. 1985 Chapter 33: fractures of small bones. pp. 325–329. *In*: Textbook of Small Animal Orthopaedics (Newton, C. D. and Nunamaker, D. M. eds.), JB Lippincott, Philadelphia.
10. Peek, G. J. and Firmin, R. K. 1995. Isolated sternal fracture: an audit of 10 years' experience. *Injury* **26**: 385–388. [Medline] [CrossRef]
11. Queitsch, C., Kienast, B., Voigt, C., Gille, J., Jürgens, C. and Schulz, A. P. 2011. Treatment of posttraumatic sternal non-union with a locked sternum-osteosynthesis plate (TiFix). *Injury* **42**: 44–46. [Medline] [CrossRef]
12. Rahman, M. M., Jeong, I. S. and Kim, N. S. 2017. Application of minimally invasive plate osteosynthesis to tibial shaft fractures in dogs. *J. Vet. Clin.* **34**: 200–203. [CrossRef]
13. Rahman, M. M., Lee, S. J., Mun, A. R., Adam, G. O., Park, R. M., Kim, G. B., Kang, H. S., Kim, J. S., Kim, S. J. and Kim, S. Z. 2014. Relationships between blood Mg2+ and energy metabolites/enzymes after acute exhaustive swimming exercise in rats. *Biol. Trace Elem. Res.* **161**: 85–90. [Medline] [CrossRef]
14. Schulz-Drost, S., Krinner, S., Langenbach, A., Oppel, P., Lefering, R., Taylor, D., Hennig, F. F. and Mauerer, A. 2017. Concomitant sternal fracture in flail chest: an analysis of 21,741 polytrauma patients from the traumaregister DGU®. Trauma Register DGU. *Thorac. Cardiovasc. Surg.* **3**: 165–254.
15. Serra, C. I., Soler, C., Moratalla, V., Sifre, V. and Redondo, J. I. 2015. Surgical management of a traumatic dislocation of the sternum in an English bulldog. *J. Small Anim. Pract.* **56**: 407–410. [Medline] [CrossRef]
16. Strauss, E. J., Schwarzkopf, R., Kummer, F. and Egol, K. A. 2008. The current status of locked plating: the good, the bad, and the ugly. *J. Orthop. Trauma* **22**: 479–486. [Medline] [CrossRef]
17. Voldby, A. W. and Brandstrup, B. 2016. Fluid therapy in the perioperative setting-a clinical review. *J. Intensive Care* **4**: 27. [Medline] [CrossRef]
18. von Garrel, T., Ince, A., Junge, A., Schnabel, M. and Bahrs, C. 2004. The sternal fracture: radiographic analysis of 200 fractures with special reference to concomitant injuries. *J. Trauma* **57**: 837–844. [Medline] [CrossRef]
19. Yeh, D. D., Hwabejire, J. O., DeMoya, M. A., Alam, H. B., King, D. R. and Velmahos, G. C. 2014. Sternal fracture--an analysis of the National Trauma Data Bank. *J. Surg. Res.* **186**: 39–43. [Medline] [CrossRef]