Successful use of dual-plate fixation to treat a canine comminuted scapula fracture

A 9-month-old, female, cross-breed dog was presented for management of a left-sided, traumatic, closed, comminuted scapula fracture that had occurred 8 days prior to presentation. Following a computed tomography scan, the fracture was stabilised via open reduction and internal fixation with a 2.7 mm 12-hole locking compression plate (DePuy Synthes, West Chester, PA) along the cranial aspect of the scapular spine. Intraoperatively, a gap was opening along the fracture line on the caudal aspect of the scapular body during shoulder extension, likely due to the large muscular distraction forces. A 2.7 mm 6-hole semitubular plate was placed on the caudal aspect of the lateral body of the scapula and secured using four cortical screws, which successfully prevented gap formation. At the time of discharge, the dog was able to bear weight on the operated left thoracic limb with a moderate lameness. At 9 weeks postoperatively, a computed tomography scan showed complete healing of the scapula fracture. At 1 year postoperatively, her owner reports no signs of lameness, stiffness or pain. In this case, dual-plate fixation allowed early return to weight bearing, successful healing by 9 weeks postoperatively and return to full function at 1 year postoperatively.

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Comminuted scapular body fractures are a relatively uncommon injury in dogs but cause substantial morbidity. The main segments of the fracture tend to tent up, leading to pain, reduced function and an increased potential for reinjury (Cook et al, 1997; DeCamp, 2015). There is no evidence-based clinical consensus on the optimum treatment of these complex fractures (Cook et al, 1997; DeCamp 2015). It is commonly accepted that conservative medical management is not recommended for comminuted fractures of the scapular body when significant displacement of fragments is present, because the lack of inherent stability and ongoing movement of the fragments can cause significant swelling and discomfort (Harari and Dunning, 1993; Cook et al, 1997; Bojrab et al, 2014; DeCamp, 2015). A longer recovery period and higher incidence of lameness may be seen in conservatively managed scapular body fractures, although case numbers are small (Harari and Dunning, 1993). A previous experimental research study of induced scapula fractures reported enhanced healing and earlier return to function when scapular body fractures were plated (Mbogwa et al, 1978). When comminution is present, bridging fixation with a bone plate allows realignment of the main fracture fragments. Without anatomic reconstruction due to the comminution, the implants must withstand the entire load of the patient during weight bearing. This can lead to implant failure through fatigue fracture or bending (Schwandt and Montavon, 2005; Morris et al, 2016; Sahu et al, 2017). In comminuted long bone fractures, it is common to add an intramedullary pin to resist the bending forces that often lead to plate failure (Hulse et al, 1997). In flat bones, it is not possible to add an intramedullary pin and this case report describes the addition of a second plate to treat a comminuted scapular body fracture.

Case presentation

A 9-month-old, female, spayed, German shepherd cross-breed dog was presented for management of a left-sided, traumatic, closed comminuted scapula fracture that had occurred 8 days prior to presentation. The details of the trauma that occurred were unknown as the patient was at a boarding facility when the fracture occurred. Medical management consisting of crate rest, leash walks and non-steroidal anti-inflammatory medication had

Table 1. Initial biochemistry profile on admission

Test	Result	Units	Reference interval
Sodium	142	mmol/L	141–150
Potassium	3.9	mmol/L	3.9–5.3
Chloride	115	mmol/L	109–119
Total CO_2	22	mmol/L	19–30
Glucose	109	mg/dL	67–132
Urea nitrogen	14	mg/dL	7–32
Creatinine	0.6	mg/dL	0.5–1.5
Total protein	5.9	g/dL	4.8–6.9
Albumin	2.5	g/dL	2.3–3.9
Globulin	3.4	g/dL	2.2–3.5
Alanine aminotransferase	81	U/L	14–87
Alkaline phosphatase	124	U/L	20–157
Packed cell volume	39	%	35–45

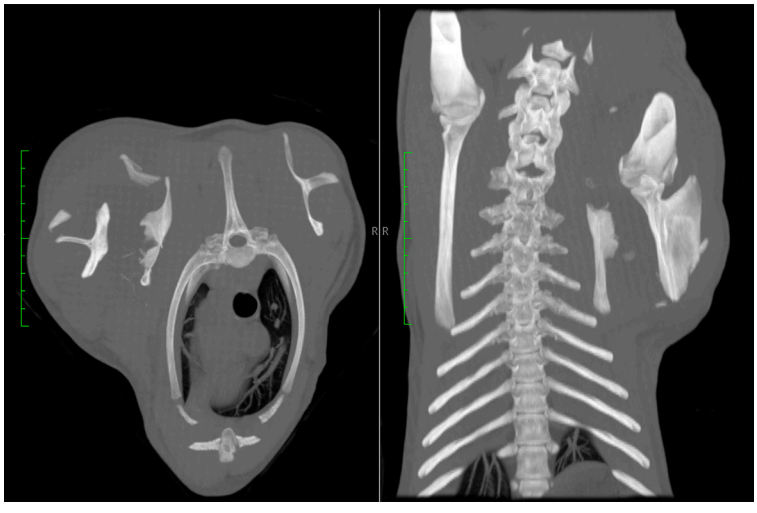

Figure 1. Preoperative computed tomography scan showing the transverse and dorsal (coronal) planes to illustrate the main fracture segments nearly completely overriding each other and the large soft tissue swelling.

been instituted immediately following the trauma. The patient remained lame, in pain and was unable to bear weight through the limb at a stance and was therefore referred for possible surgical management.

Clinical examination

The patient was bright, alert and responsive although her owner reported she had been quieter than normal. Her heart rate and temperature were mildly elevated at 150 beats per minute and 39.6°C, deemed secondary to excitement and discomfort. All other vital parameters were within normal limits. A large, round, firm soft tissue swelling was present over the area of the left scapula and there was moderate ventral oedema along the sternum. There were no skin wounds or evidence of bruising at the time of examination. The patient had a moderate to severe weight bearing left thoracic limb lameness (four-fifths) at walk and trot. At a stance, she did not bear weight through the left thoracic limb. A pain response was elicited when the left shoulder was flexed, and crepitus was palpable over the left scapula region. The patient was not able to tolerate any shoulder extension because of the discomfort. Under sedation, the range of shoulder extension was moderately reduced. The patient was positive for Ortolani bilaterally and there was a mild intermittent crepitus during extension of the left coxofemoral joint. The remainder of the orthopaedic examination was within normal limits. Preoperative pack cell volume, total protein and a biochemistry investigation were all within normal limits *(Table 1)*.

Preoperative imaging

A thoracic and scapular computed tomography scan was performed under sedation to further investigate the scapula fracture and to screen the thorax for any concurrent injuries. The left scapular body fracture was highly comminuted with marked caudal, proximal and lateral displacement of the distal segment, with approximately 75% overriding of the proximal segment *(Figures 1* and *2)*. Multiple bone fragments were present in the surrounding soft tissues. A very large area of haemorrhage or haematoma was present surrounding the fractured scapula, measuring 10 x 6 x 11 cm. The left axillary lymph node was mildly enlarged and rounded compared to the right. A healing, non-displaced, closed fracture of the distal portion of the sixth right rib was identified.

Surgery

The patient was anaesthetised and positioned in right lateral recumbency. A standard lateral approach to the scapular body was made (Piermattei and Johnson, 2004). A large haematoma was immediately encountered and had to be removed via lavage and suction to allow visualisation of the scapula and musculature. The infraspinatus muscle had a midbody tear secondary to the trauma with only approximately 10% of fibres remaining intact. The suprascapular nerve was identified and confirmed to be intact, and a vessel loop was passed around the nerve to aid identification throughout the procedure. The main distal and proximal scapular fragments were identified, and manual traction was applied to realign the fragments. Pointed reduction forceps were used to assist manipulation of the fragments. Maintaining alignment of the two main segments was challenging and a loop of orthopaedic wire was placed through the scapular spine of the proximal segment and a separate loop through the scapular spine of the distal segment. These loops were then used as handles to allow the segments to be held in alignment whilst a plate was applied. A 2.7 mm 12-hole locking compression plate (DePuy Synthes, West Chester, PA) was applied along the cranial aspect of the scapular spine and secured using four cortical screws and seven locking screws, with five screws placed in the distal fragment and six screws placed in the proximal fragment. The screws were placed at an approximately 45° angle to maximise bone purchase (Ocal and Toros, 2007). The loops of orthopaedic wire were removed, and the limb was then placed through range of motion. A large

gap was opening along the fracture line on the caudal aspect of the scapular body during shoulder extension, likely due to the large distraction force of the triceps brachii which originates on the distal half of the caudal scapula. A 2.7 mm 6-hole semitubular plate was placed on the caudal aspect of the lateral body of the scapula and secured using four cortical screws. This successfully prevented gap formation during shoulder extension intraoperatively and maintained the main proximal and distal fragments in alignment and apposition. The surgical site was lavaged and any loose large fragments were approximated into the fracture gap prior to closure. The infraspinatus tendon muscle was opposed with 2-0 Maxon (Covidien, Medtronic, Minneapolis, Minnesota, USA) with cruciate interrupted sutures. The fascia was closed using 2-0 Maxon in a simple continuous pattern, subcutaneous tissues were closed with 2-0 Biosyn (Covidien, Medtronic, Minneapolis, Minnesota, USA) and the skin was opposed with 3-0 Biosyn in an intradermal pattern. A Primapore dressing (Smith & Nephew, Memphis, Tennessee, USA) was applied to cover the surgical site. Postoperative radiographs *(Figure 3)* showed mild lateral displacement of the distal fragment but acceptable overall alignment, restoration of length and appropriate implant positioning and screw lengths. A Velpeau sling (DogLeggs, York, Philadelphia, USA) was applied prior to anaesthesia recovery with the shoulder, elbow and carpus in flexion.

Postoperative care

The patient regurgitated during general anaesthesia and pantoprazole at 1 mg/kg was administered intravenously. A 7-day course of oral omeprazole at 1 mg/kg every 12 hours was prescribed. The patient also had some diarrhoea and therefore the nonsteroidal anti-inflammatory drug, carprofen, was stopped. At the time of extubating, the packed cell volume had decreased to 23%. The patient's heart rate and blood pressure were monitored during recovery. Four hours postoperatively, her blood pressure had a mean of 60 mmHg with a diastolic of 50 mmHg and systolic of 90 mmHg. The heart rate was mildly elevated at 140 beats per minute. Multiple crystalloid fluid boluses had failed to maintain a rise in blood pressure and therefore a whole blood transfusion (200 ml over 4 hours) was administered following typing of the patient. The blood pressure, heart rate and packed cell volume all slightly increased following the transfusion and the patient was discharged 2 days postoperatively. At the time of discharge, she was able to bear weight on the operated left thoracic limb with a moderate lameness with mild increased flexion of the carpus secondary to the Velpeau sling. The leg position was modified within the Velpeau so that the shoulder and elbow were flexed but the carpus remained at 0° with the foot just visible at the cranial edge of the sling. This was modified to prevent worsening carpal flexion or a flexural contracture occurring. The owners were instructed to remove the sling for controlled leash walks of 5 minutes duration twice daily for the first week, with increasing time without the sling whilst in her crate over 1 week. After one week, the Velpeau sling was removed. Physical therapy exercises were performed by the owner three times daily as instructed by the physical therapist. A gradually increasing walking regime was advised.

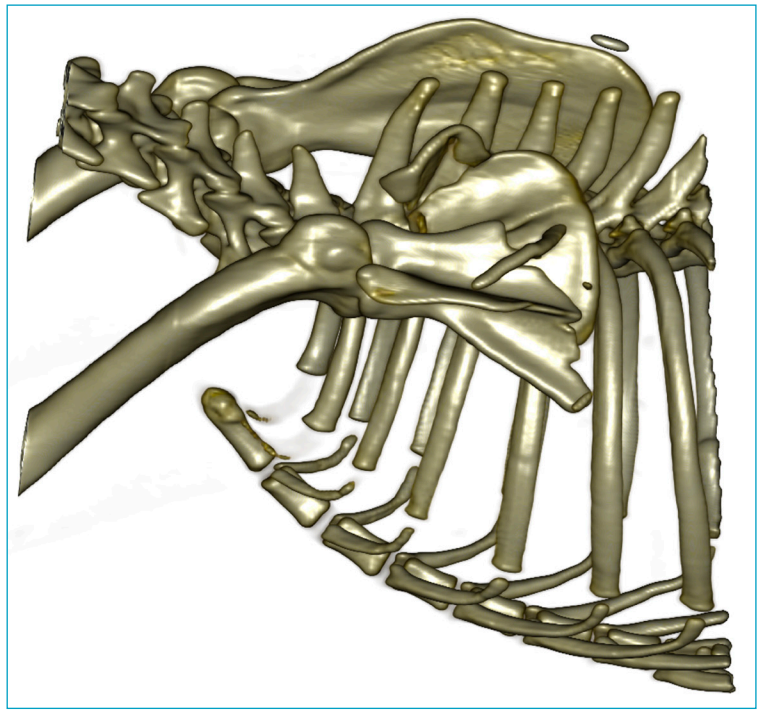

Figure 2. 3D volume rendering of the preoperative computed tomography scan to illustrate the two large fracture segments. Many of the smaller bony fragments are not visible on this view due to the algorithm used.

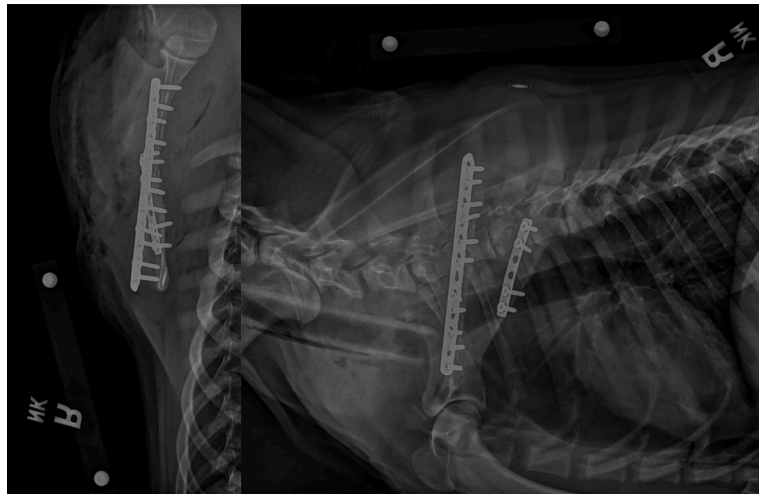

Figure 3. Immediate postoperative radiographs show restoration of scapular length, acceptable alignment of the main fragments and appropriate implant placement and screw length. Screws are angled at 45 degrees caudally to maximise bone purchase as suggested by Orcal and Toros (2007).

Follow up examination

Nine weeks postoperatively, the patient returned for a scheduled recheck examination. She walked with an intermittent very mild (one-fifth) left thoracic limb weight bearing lameness and there was a mild reduction in left thoracic limb muscle mass compared to the right *(Figure 4)*. The range of motion of all left thoracic limb joints was normal with no restriction of shoulder extension

Figure 4. There is a mild reduction in muscle mass over the left scapula compared to the right.

or flexion, and the previous mild carpal flexion had completely resolved. No crepitus or pain could be elicited. A Liverpool osteoarthritis in dogs questionnaire was completed, and she had a score of 7 which correlates to mild osteoarthritis according to the recommended interpretation scale.

A computed tomography scan of the left scapula was performed which showed complete healing of the scapula fracture with static implant positioning and no implant related complications (*Figure 5*). Within the acromial head of the deltoid tendon, there were multiple small mineral opacities consistent with enthesopathy. A gradual return to activity was instructed and at 1 year postoperatively her owner reports no signs of lameness, stiffness or pain.

KEY POINTS

- Comminuted scapular body fractures are uncommon but cause substantial morbidity.
- Open reduction and internal fixation can allow early return to weight bearing and lead to a full functional recovery.
- There are large tensile forces acting along the caudal scapular body from the triceps and teres minor muscles distally, and the rhomboideus and teres major muscles proximally – these should be taken into account when planning a repair.
- The scapular spine and caudal edge of the scapula have adequate cortical bone stock for implant purchase in a large breed dog.
- Dual bone fixation of the scapula can provide enough strength and stiffness to allow immediate postoperative weight bearing.
- In patients with large fracture haematomas, blood product may be required for haemodynamic stabilisation.

Discussion

This case report describes the successful application of dual-plate fixation on the scapula of a dog. Moving the second plate to the caudal edge of the scapula prevented the gap formation that was occurring secondary to the tensile forces from the triceps brachii (long head) and teres minor muscles distally, and the rhomboideus and teres major muscles proximally (Hermanson et al, 2018). The caudal plate avoided the suprascapular nerve, and it was possible to place cortical screws in this area due to the increased thickness of the bone and the presence of two distinct cortices. In this case there was no evidence of any screw loosening or screw pull out, even in the caudal semi-tubular plate where only cortical screws were used.

Previous work has suggested that the greatest bone purchase in the scapula is achieved if screws are placed along the scapula spine at an angle of 45° (Ocal and Toros, 2007). However, the caudal edge of the scapula has a similar volume of cortical bone available, yet studies have failed to highlight this as a possible area for implant placement. Further work, which considers the muscular forces acting on the scapula, is required to investigate whether the caudal edge of the scapula or the scapular spine offers a biomechanical advantage for implant placement.

The use of a single bone plate in comminuted long bone fractures can lead to implant failure through fatigue fracture or bending (Schwandt and Montavon, 2005; Morris et al, 2016; Sahu et al, 2017). The addition of a second plate improves construct strength, may reduce the incidence of implant failure and allow immediate postoperative weight bearing through the operated limb (Castaldo et al, 2021; Coleman et al, 2023). In an ex vivo biomechanical study of simulated scapula fractures, a dual plate approach did not show a biomechanical strength advantage in a simple osteotomy model (Mair et al, 2003). This study did not accurately model a comminuted fracture since there was no gap between the fragments. This study also used two plates near each other on either side of the scapular spine, and this may have lessened the overall biomechanical advantage of having two plates.

A blood transfusion was administered to support this patient during her postoperative recovery. It is important to note that where large fracture haematomas are present, significant blood loss can occur intraoperatively and vital parameters should be closely monitored for signs of hypovolaemia. Pelvic and femoral fractures are often associated with large fracture haematomas and can require blood transfusion for perioperative stabilisation (Lynch et al, 2015).

This patient was placed in a Velpeau sling for 1 week postoperatively with intermittent walks without the sling in place. The sling was placed to prevent immediate uncontrolled weight bearing postoperatively in a young and lively patient but may have been unnecessary with the use of double plate fixation. Further studies are required to investigate whether the addition of a second

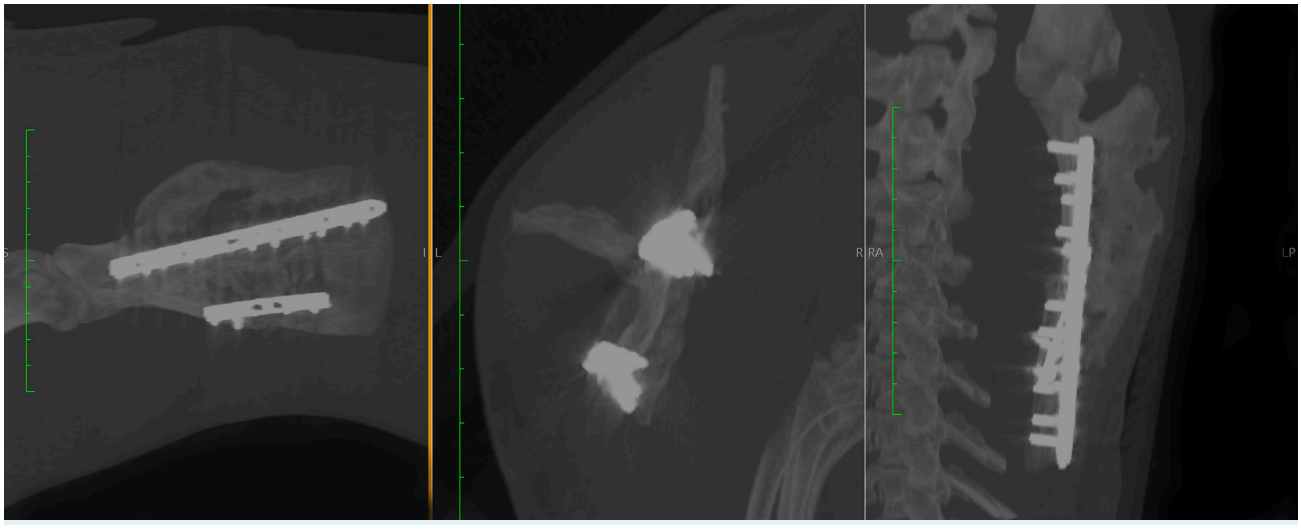

Figure 5. 9 weeks postoperative computed tomography scan, sagittal, transverse and dorsal (coronal) views show static implant positioning and successful bridging bony callus across the fracture.

plate in highly comminuted fractures confers enough strength and stiffness to allow early weight bearing by the patient. A Spica splint could also have been used for postoperative immobilisation, but does not offer the ability to remove it intermittently throughout the day to allow for controlled weight bearing. Early return to weight bearing allows improved muscular recovery, prevents potentially irreversible cartilage damage and avoids disuse osteoporosis (Palmoski and Bean, 1988). Therefore, surgical treatment should aim to return the patient to weight bearing as soon as possible. At only 9 weeks postoperatively, the patient had a low Liverpool osteoarthritis in dogs score, indicating good clinical function of the limb. Whilst this is an imperfect assessment of outcome in a non-articular fracture, it provides some context to the orthopaedic examination and imaging findings to allow a more objective assessment of patient outcome.

In this case, dual-plate fixation allowed early return to weight bearing, successful healing by 9 weeks postoperatively and return to full function at one year postoperatively. Further investigation into the benefit of dual bone fixation for comminuted scapula fractures and the impact of plate positioning is required to further guide clinicians. CA

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Conflict of interest

The author states that there are no conflicts of interest.

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