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Internal fixation of a comminuted metacarpal fracture in a bull

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SUMMARY

An 11-month-old pedigree Simmental bull weighing 450 kg was presented with a closed, displaced, oblique, comminuted fracture of the left metacarpal III/IV bone. The two main bone fragments were reduced using two 5.5 mm cortical screws placed in lag fashion across the oblique portion of the fracture. A 4.5 mm broad dynamic compression plate was then used to stabilise the fracture site. General anaesthesia was maintained with isoflurane in 100 per cent oxygen and multimodal analgesia during surgery was provided with a ketamine constant rate infusion and ulnar nerve block. The limb was cast for a total of 12 weeks following surgery, with one cast change carried out at four weeks postoperatively. The bull was used successfully for natural service from nine months postoperatively. The high cost of treatment means that internal fracture fixation is only commercially viable in valuable pedigree animals. Availability of facilities for anaesthetising large animals is another limiting factor.

BACKGROUND

Orthopaedic surgery is rarely undertaken in an animal of this size as the prognosis is assumed to be poor, especially with a comminuted fracture. This case reports successful fracture reduction and stabilisation via internal fixation, coupled with use of external coaptation to improve stability of the implants and support recovery. There are few published reports of internal fixation being used for fracture repair in a bovine of this size.

In addition, anaesthesia and analgesia is challenging in this case due to the paucity of licensed drugs available to provide adequate analgesia in food-producing animals. For example, opioids, which are one of the classes of drugs most commonly used to provide multimodal analgesia and perioperative pain relief in veterinary medicine, cannot be used due to lack of maximum residue limits (MRLs). A constant rate infusion (CRI) of ketamine and regional anaesthetic techniques were used to control pain intraoperatively. These promoted fast recovery from anaesthesia and use of the affected limb.

CASE PRESENTATION

The bull was housed in a straw pen with his dam and was found to be non-weightbearing on the left forelimb. The attending veterinary surgeon applied a Robert Jones support bandage and administered meloxicam (0.5 mg/kg Metacam, Boehringer Ingelheim) subcutaneously before loading the bull for transport. The bull was potentially of high value and therefore was referred for treatment.

INVESTIGATIONS

There were no significant abnormal findings on general clinical examination, except for the severe left forelimb lameness. The presence of the Robert Jones bandage precluded examination of the injured limb in the first instance. The bull was sedated with xylazine (0.05 mg/kg Sedaxylan, Dechra) intramuscularly to facilitate radiography.

Initial radiographs taken with the Robert Jones bandage in place revealed a 45° proximolateral-distomedial oblique fracture of the left metacarpal III/IV (MCIII/IV) bone with additional radiolucent lines in the dorsal cortex and an additional separate bone fragment on the lateral cortex. The distal portion of the proximal fragment was displaced dorsally and medially, leaving less than 30 per cent contact between the two main fragments at the fracture site (Fig 1a). No gas pockets could be seen within the skin, suggesting a closed fracture. Given the type of fracture and the size of the patient, open reduction and internal fixation was recommended.

Preoperative radiographs were used to determine the ideal plate lengths and the number and length of screws that would be required. Intraoperative radiographs were used to facilitate fracture reduction and to ensure accurate implant positioning.

TREATMENT

Ceftiofur was administered preoperatively (6.6 mg/kg Naxcel, Zoetis) subcutaneously at the base of the ear. General anaesthesia was induced with intravenous ketamine hydrochloride (5 mg/kg Ketamidor, Chanelle). To obtain the correct depth of anaesthesia for intubation, thiopental (1 g, Thiopentone, Ilium) was administered intravenously followed by a further 2 mg/kg ketamine. The trachea was intubated by blind digital palpation with a 20 mm cuffed endotracheal tube, which was connected to a large animal circle breathing system (Mallard Medical). General anaesthesia was maintained with isoflurane in 100 per cent oxygen (IsoFlo 100%, Zoetis), supported by a CRI of ketamine hydrochloride at 5 µg/kg/minute. An ulnar nerve block was performed to provide multimodal analgesia. The site for the ulnar nerve block was palpated approximately 10 cm proximal to the accessory carpal bone on the palmarolateral surface of the radius in a groove between flexor carpi ulnaris and flexor carpi lateralis.[1] A 20 G 2″ needle was used to inject 10 ml

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of 2 per cent lidocaine hydrochloride (Lidocaine Injection 2%, Hameln). Once internal fixation was complete, infiltration of the surgical area with 20 ml of 2 per cent lidocaine hydrochloride was performed to provide some postoperative analgesia.

The bull was positioned in right lateral recumbency with the limb prepared for aseptic surgery from the level of the distal radius to the digit. Following draping, a 30 cm curvilinear incision was made on the dorsolateral aspect of the third metacarpal extending distally from the distal carpal bones to the level of the metacarpophalangeal joint. The subcutaneous tissue was undermined using Metzenbaum scissors and the obtained skin flap was reflected dorsomedially. The lateral digital and common long digital extensor tendons were identified and elevated away from the metacarpal bone to expose the fracture site. An oblique, complete, displaced and comminuted fracture was appreciated. A few bone fragments were removed from the fracture line. The fracture was initially reduced using bone reduction forceps and a 50 mm 5.5 cortical screw was placed in lag fashion on the proximal aspect of the MCIII/IV. Increased stability was obtained and an eight-hole dynamic compression plate (DCP) was placed on the dorsal aspect of the bone. Three 5.5 cortical screws were placed proximally to the fracture line, engaging the proximal three holes of the DCP and four 5.5 cortical screws were placed distally. No screw was placed in the fourth hole (from proximal) due to the hole being exactly over the fracture line. After the plate was placed, another 5.5 cortical screw was placed in lag fashion on the lateral aspect, approximately 2 cm distal to the previous lag screw to gain further compression in the lateromedial plane. The site was thoroughly lavaged with a solution of 500 ml normal saline containing 1 g ceftiofur (Excenel, Zoetis). The surgical wound was closed in two layers. The subcutaneous tissue was closed using 3M lactomer 9-1 (Vicryl) in a continuous horizontal mattress pattern. The skin was closed using 3.5M polypropylene (Prolene) in an interrupted horizontal mattress pattern. The surgical site was then covered with an absorbable dressing (Primapore, Smith & Nephew) and sterile bandage. A full-limb cast (Delta Cast, BSN medical) was applied from the elbow distally, enclosing the hoof and extending to the elbow. Postoperative radiographs showed the final position of the screws and plate (Fig 1b).

Anaesthesia time was 300 minutes and surgery time was 240 minutes. Despite the length of the procedure, recovery from anaesthesia was uneventful; however, signs of right-sided facial paralysis due to compression of the facial nerve during surgery were noted, with this abnormality resolving within three days. The bull stood 25 minutes after disconnection from inhalant anaesthetics but was unwilling to bear weight on the cast immediately. Biochemistry was performed after recovery revealing an increase in creatine kinase (1353 U/l; reference range 0–350) which was not unexpected due to the duration in lateral recumbency on the operating table with possible associated mild muscle damage. All other parameters were within normal limits. Within 24 hours the bull was able to stand and to bear weight on the cast consistently without encouragement. Meloxicam (0.5 mg/kg Metacam, Boehringer Ingelheim) was given subcutaneously every 48 hours for three doses, then every 72 hours for a further three doses. Ceftiofur (6.6 mg/kg Naxcel, Zoetis) was administered at the base of the ear weekly. In total, the bull was treated with antimicrobial therapy for three weeks.

Radiographs obtained four weeks postsurgery (Fig 1c) revealed that the plate and screws were stable with evidence of periosteal new bone production at the fracture margins, indicating the start of fracture healing. The cast was changed under sedation with 0.1 mg/kg xylazine administered intramuscularly (Sedaxylan 2%,

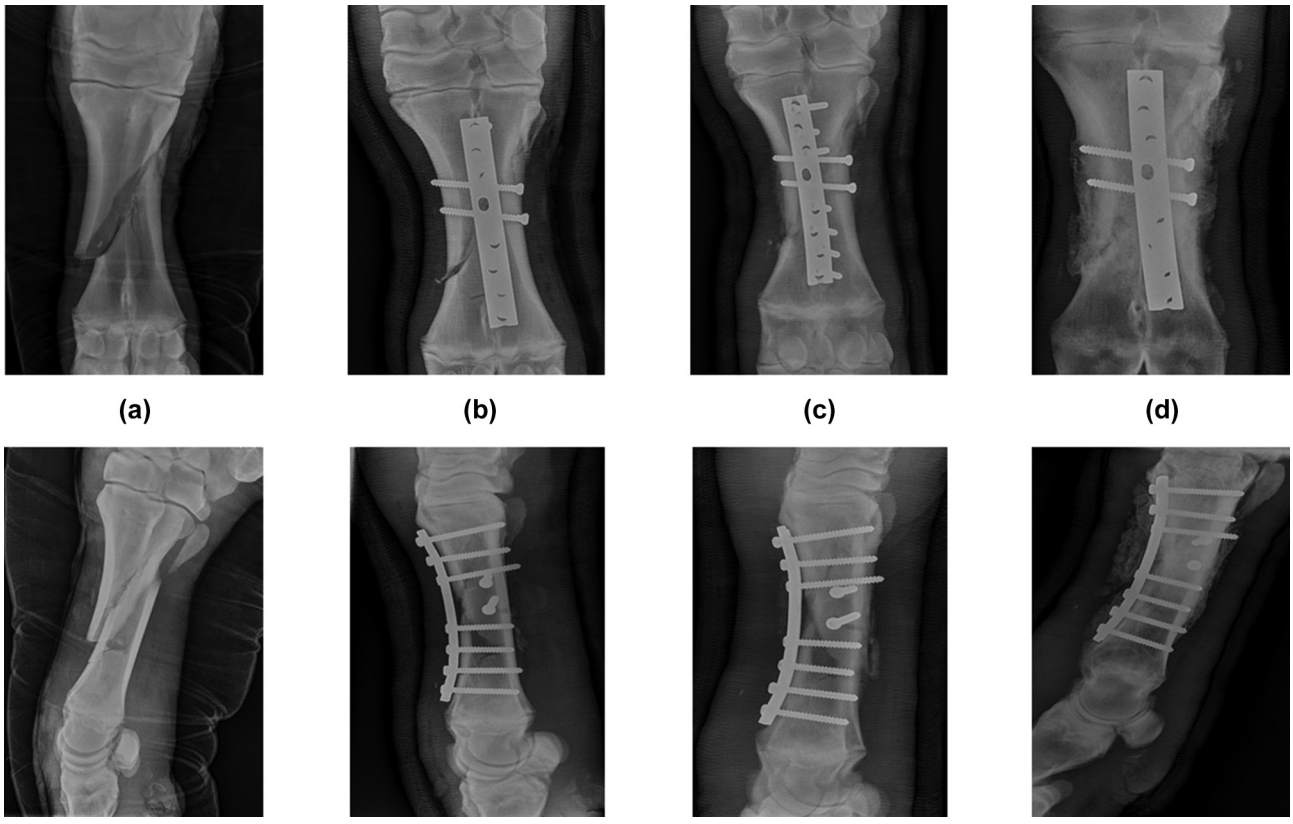

FIG 1: Dorsopalmar and lateral radiographs of distal left metacarpal III/IV (MCIII/IV) showing the original fracture and the internal fixation, along with the progression of healing. (a) Preoperative. (b) Postoperative. (c) Fours weeks postoperative. (d) Twelve weeks postoperative.

Dechra) followed by intravenous top-ups of 0.05 mg/kg xylazine every 15 minutes. The surgical wound was dry and free from discharge (Fig 2). The sutures were removed. A new cast was placed as the initial limb swelling had reduced over time.

Radiographs obtained nine weeks postoperatively showed increased radiodensity at the oblique fracture line. Further palisading periosteal new bone formation could be seen circumferentially around MCIII/IV, particularly on the dorsal aspect; however, the main fracture line was still radiolucent. Radiographs at 12 weeks postsurgery demonstrated clear callus formation along the fracture site and at the margins, with the main fracture site less obvious due to an increase in radiodensity (Fig 1d). Therefore, the cast was removed under sedation. The caudal aspect of the cast was able to be preserved and incorporated into a bandage to act as a splint, which was left in place for a further week to prevent injury to the ligaments and tendons of the lower limb which had developed tendon laxity due to immobilisation. The bull was notably lame and judged as 4/5 by the Manson and Leaver system of locomotion scoring (obvious lameness, some difficulty turning, behaviour pattern affected),[2] although it was unclear what proportion of the lameness was due to pain as opposed to functional lameness caused by disuse. Meloxicam was administered (0.5 mg/kg Metacam, Boehringer Ingelheim) at the time of splint application, followed by a second dose 72 hours later, after which time the lameness had improved. The bull continued to improve after the splint was removed and he was discharged home one week after cast removal.

OUTCOME AND FOLLOW-UP

One year postoperatively, the farmer reported that the bull was not lame; however, there was visible thickening of the MCIII/IV region, likely the result of callus and fibrous tissue formation at the fracture and surgical sites, respectively. The bull had been housed individually on his return home for a six-month period, during which time he was walked on a halter around a large yard once or twice daily, and was used for semen collection on the farm. From nine months postsurgery, the bull was turned out to be used for natural service on a group of heifers. At the time of writing the farmer had reported that 15 heifers were known to be in calf, and the bull was still working.

DISCUSSION

Metacarpal/metatarsal III/IV bones are the most common site of bovine long bone fractures.[3] The management of bovine fractures is complicated by circumstances and expectations, and the significant influence of economic factors. In their favour, most cattle are cooperative patients that usually spend a significant amount of time lying down during convalescence which prevents overloading of bone implants.[4] Cattle also have enhanced potential for bone healing due to increased vascular density in their bones and a well-developed osteogenic layer in the periosteum. They are also unlikely to suffer problems in the unaffected limbs due to increased weightbearing.[5] In the current case, prompt stabilisation of the fracture by external coaptation at the time of occurrence improved prognosis by preventing a closed fracture from becoming open, preventing further fracture fragmentation and reducing eburnation of the fracture ends.[3]

There is a moderate body of published literature relating to management of fractures in the bovine animal, but predominantly in younger and lighter animals than in the current case. The most commonly described conservative management is the use of Thomas splint and cast combinations for treatment of radial and ulnar fractures.[6–9] The use of casts alone—now most often constructed from fibreglass material—is accepted as a standard method for treatment of phalangeal and metacarpal/metatarsal fractures.[5] External coaptation is most appropriate for fractures in which rapid fracture healing can be expected, such as with simple transverse fractures or simple oblique fractures with more than 50 per cent overlap of the fracture ends, where closed reduction is likely to be achieved.

Reported surgical fracture treatments in cattle include external fixation techniques such as the use of circular external skeletal

(a) (b)

FIG 2: Photographs during cast changing four weeks postoperatively. (a) The surgical wound. (b) The second cast in place with the bull sedated in lateral recumbency.

fixators[10 11] or transfixation pins.[12 13] Reported internal fixation techniques in cattle include intramedullary pinning,[14 15] clamp rod internal fixators[16] and use of DCPs.[5] Internal fixation techniques are more surgically invasive and expensive, but they allow optimal fracture reduction and intrafragmentary compression, and greater biomechanical stability compared with external fixation techniques.[5]

Most relevant to the current case, there are previous reports of the use of DCPs for treatment of metacarpal fractures,[14 17] particularly in calves where the injury was sustained due to application of excessive force by calving ropes or chains during calving. DCPs have also been used successfully in heavier animals (>200 kg). A recent review reported such cases, with a positive outcome noted for 8/12 cases.[18] Internal fixation using DCPs remains the 'gold standard' for large animal fracture repair, particularly where high performance standards are expected such as in breeding or show animals.[16] The lag screws and DCP used in this procedure were acting to appose bone fragments, but the support provided would be insufficient to resist bending forces applied by the weight of the bull. External coaptation was needed to provide adequate support. The use of two plates, one dorsally and one laterally, has been described in previous literature for repair of a metatarsal fracture.[19 20] Unfortunately, fissure lines on the lateral aspect of the bone ruled out the use of a full-length lateral plate and screws (Fig 1b).

Successful repair of a comminuted metacarpal fracture using a different technique to the current case has been reported in an 870 kg bull.[12] Surgery was carried out to place two transfixation pins in the distal diaphysis and metaphysis of the radius. The pins were kept in place for one month incorporated in a full-limb resin cast, which was reinforced laterally with an iron bar. Surgical time was much shorter than the current case (95 minutes v 300 minutes). The limb was supported by a cast for approximately 15 weeks in total, followed by placement of a Robert Jones bandage for a further seven weeks. The outcome was comparable to the current case: the bull was able to return to work within 7.5 months and was used for four years. The authors acknowledged that internal fixation might have provided more stable repair; however, it had not been possible due to the fracture configuration.[12] The use of internal fixation in the case presented here promoted faster healing, evidenced by reduced time needed in a cast and only one week of further support with a splint. However, the bull in the current case was significantly smaller (450 kg v 870 kg).

Pain management in farm animals in general is challenging due to the lack of licensed drugs available. According to Schedule Four of the Veterinary Medicine Regulations,[21] unlicensed drugs can be used, following the cascade, to avoid 'unacceptable suffering' of the animal. The trauma that causes a fracture, orthopaedic surgery and the healing process are undeniably painful and multimodal analgesia is required to avoid the aforementioned 'unacceptable suffering'. In this case report, ketamine CRI was used for intraoperative analgesia. Ketamine is an N-methyl-D-aspartate antagonist commonly used in small animal practice as adjunct analgesia; its use has also been reported in ruminants, both for maintenance of anaesthesia and for intraoperative analgesia. Ketamine is not licensed for use as a CRI in any species, but the cascade can be applied.

A peripheral nerve block was also performed as part of the multimodal analgesia approach. The ulnar nerve block used inhibits only sensory innervation to the metacarpal region and should not risk compromising ambulation after surgery. Procaine is the only licensed drug in UK for food-producing species, but its duration of action is short (45–60 minutes); for this reason, lidocaine hydrochloride, which is licensed in horses for locoregional anaesthesia and has a longer duration of action (up to 120 minutes), was used instead under the cascade. According to table 1 of EU regulation 37/2010, no MRL is required for ketamine or lidocaine; however, the latter applies only to Equidae. The European Medicines Agency's Committee for Medicinal Products for Veterinary Use has recently stated that risk to consumers from lidocaine residues is negligible following application of a 28-day standard withdrawal period for meat.[22] Isoflurane is also unlicensed for use in cattle; however, the product used in this case (IsoFlo 100%, Zoetis) has an MRL and is licensed for use in horses with a meat withdrawal of two days. Since there was no possibility of the bull being slaughtered and entering the food chain in the foreseeable future, the risk to consumers was considered negligible following the application of a standard 28-day withdrawal period.

A broad-spectrum antimicrobial was selected in this case and used preoperatively; however, ceftiofur takes 12 hours to reach maximum plasma levels. Since surgery was prolonged and the wound was opened for a long time, we erred on the side of caution by also administering topical antibiotic of the same class to ensure the concentration at the surgical site was adequate in the short term. An infection establishing on the implant, or osteomyelitis, would have been catastrophic. The decision to use a third-generation cephalosporin was dominated by the practicality of administration: daily intramuscular injections for a prolonged period would likely have caused extensive muscle bruising and made the bull difficult to handle. There are no other broad-spectrum antimicrobials licensed for use in cattle that were considered long acting enough.

In summary, the prognosis for fractures of MCIII/IV in adult bovines repaired surgically appears favourable despite their heavy weight. There are few reports of failed surgical management; however, it is possible that this evidence is subject to reporting bias. The low number of orthopaedic surgeries requiring internal fixation carried out in general farm animal practice is likely due to economic and practical limits rather than prognostic factors for long-term survival.

It is difficult to estimate the true commercial cost of treating this case. One would need to consider the cost of five hours of anaesthesia, four hours of surgical time, the cost of the DCP and lag screws, medication, radiographs, casting materials and time for cast changing. This bull was hospitalised for 12 weeks, but it would be possible to avoid hospitalisation charges if an owner is willing to care for the patient on-farm. However, in this case the owner opted for prolonged hospitalisation and a perceived more rigorous observation of the bull during the healing process. Overall, the decision to proceed with a potentially expensive course of treatment rests with the owner, who is in the best position to make the economic judgements in relation to the potential income of the bull in the long term.

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