Biaxial proximal interphalangeal joint hyperflexions in a five-year-old Holstein bull

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SUMMARY
A five-year-old Holstein bull became lame after dismount during semen collection. Swelling of the pastern of the left front limb was noted. Radiographic images showed biaxial hyperflexion of the proximal interphalangeal joints in digits III/IV without hyperextension of the metacarpophalangeal joint. Conservative management (stall confinement and NSAIDs) failed to resolve the lameness. External coaptation to stabilise the joint failed to prevent hyperflexion of the joint within the cast and to improve comfort. Pressure sores developed after seven days. Surgical arthrodesis of the PIP joint was performed on each digit by application of a locking compression plate. The bull healed and arthrodesis of the joints progressed over the next 16 weeks. At that time, the bull was walking sound and was returned to semen collection. One year after surgery, the attending veterinarian reported that the bull remained sound at a walk and was still being used for semen collection.

BACKGROUND
Lameness is common in all types of cattle, and veterinarians are frequently asked to diagnose, treat and provide a prognosis for lame cattle. Diseases of the proximal interphalangeal joint are uncommonly reported. The most common problems affecting the proximal interphalangeal (PIP) joint are sepsis and trauma, either of the bones or the supportive soft tissue. In particular, hyperflexion of this joint is rarely reported in cattle. Lameness associated with hyperflexion of the joint can range from a mild lameness to a non-weightbearing lameness. Lameness examination, physical examination and careful palpation of the limb by the veterinarian can result in a presumptive diagnosis. Definitive diagnosis is obtained using radiographic imaging. Proximal interphalangeal joint hyperflexion can occur as a uniaxial or biaxial condition and is invariably secondary to injury of the supportive palmar/plantar tendons and ligaments. Treatment of proximal interphalangeal joint hyperflexion may include stall confinement, NSAID therapy, application of a splint or cast, facilitated ankyloses of the joint, or surgical stabilisation of the joint for the purpose of arthrodesis. Non-surgical methods are unlikely to restore the PIP joint to normal. Outcomes with surgical treatment of PIP joint hyperflexion in adult cattle are unknown, likely because of economic constraints and a perception of poor prognosis for productivity and longevity. As a result, cattle having proximal interphalangeal joint injury may be left untreated and suffer chronic pain and lameness or may be culled from the herd and salvaged for meat. Surgical options most often are performed in calves or youngstock. Surgical options often are not offered to owners for adult cattle, especially adult bulls, because of their weight and extreme forces applied to the limb during ambulation. Recently, locking plate technologies have been introduced to veterinary surgeons as a tool for providing superior stabilisation of small-sized bone segments and for use in compromised bone. In this bull, the authors had an opportunity to use locking compression plates to achieve rigid stabilisation of the proximal interphalangeal joint after surgery as a means of increasing the likelihood of successful arthrodesis of the joints. Arthrodesis was expected to result in pain-free ambulation, which would allow the bull to continue to be used in its commercial capacity as a semen production bull.

CASE PRESENTATION
A five-year-old Holstein bull used for commercial semen production was presented for chronic lameness (severity ranged from grade 2 to 3 out of 5) of the left front limb of more than 30 days in duration. Lameness worsened over time, and the lameness was first classified as a grade 2 and progressed to a grade 3 lameness before admission. The bull was housed individually at a professional bull stud. The bull had suffered a fall after semen collection resulting in its lameness. The bull was treated at the farm with stall confinement and meloxicam (0.5 mg/kg, orally, every 48 hours). The lameness mildly improved but persisted after 30 days of stall rest. Because of the bull’s economic value, it was referred to the surgical hospital for diagnostic work-up and generation of a treatment plan. At the time of admission, the bull weighed 1200 kg, and had a rectal temperature of 39.4°C, heart rate of 80 beats per minute and respiratory rate of 40 breaths per minute. The bull had normal faecal output and consistency, and urinated without difficulty during the examination.

INVESTIGATIONS
Lameness examination revealed a moderate left front limb lameness that was judged to be a lameness score of 2 out of 4. Visual examination and palpation of the left forelimb revealed an abnormal alignment of the pastern of both digits III and IV. On palpation, dorsal swelling of both digits were revealed to be hard and consistent with the distal end of the first phalanx and proximal end of the second phalanx. Ultrasonography examination of the digital joints revealed dorsal hyperflexion of the
proximal interphalangeal joints of both digits, and normal joint fluid appearance and volume. Ultrasonography of the tendons and ligaments associated with the fetlock and pastern showed irregular echotexture and fluid accumulation surrounding these structures. These findings were consistent with strain injury of those palmar structures; interosseous ligament and digital flexors tendons. Radiographic examination of the foot, including the pastern and fetlock, confirmed the presence of moderate soft tissue swelling, biaxial dorsal hyperflexion of the pastern joints and mildly dropped metacarpophalangeal joint (figure 1).

DIFFERENTIAL DIAGNOSIS

Differential diagnosis for left forelimb lameness in cattle is most commonly associated with disorders of the foot, and more specifically the claws or the interdigital space. Careful inspection and examination of the foot is required to rule out distal limb abnormalities before focusing on the more proximal aspects of the limb. Diseases of the PIP joint, metacarpophalangeal joint, proximal sesamoid bones and ligaments are less common compared with claw-related problems. Clinical methods for differentiating these diseases most commonly involve history, observation, physical examination of the animal, lameness examination, close inspection and palpation of the limb, ultrasonic examination, radiographic examination, and cytology. Ancillary diagnostic tools can also include high-definition thermal imaging of the affected limb. These tests are less frequently done and are most commonly reserved for cases where the cause of the lameness cannot be identified or localised.

Differential diagnoses include proximal phalanges fractures, pastern luxation, proximal sesamoid bone fracture or interosseous muscle injuries.

Figure 1 Radiographic images (a: lateromedial; b: dorsopalmar) of the left front fetlock obtained standing with the bull bearing weight on its leg. A hyperflexion of the proximal interphalangeal joint of both digits III and IV is present with a broken digital axis (arrow). The proximal sesamoid bones are located on the distal aspect of the metacarpophalangeal joint (arrowhead). A mild circumferential soft tissue thickening of the metacarpophalangeal joint is present.

Figure 2 Radiographic image revealing failure of cast immobilisation to maintain closed reduction of hyperflexion of the proximal interphalangeal joint of both digits III and IV (a: lateromedial; b: dorsopalmar).

TREATMENT

Initial treatment of this bull included placement of a cast extending from the ground to the proximal metacarpus in an attempt to stabilise the proximal interphalangeal joint. The bull was anaesthetised, the foot was trimmed and closely inspected for issues related to the sole, hoof wall or interdigital space. Traction was placed on the limb by drilling holes through the hoof wall at the toe through which heavy gauge wire was looped. These were attached to an electric winch until sufficient tension was achieved to reduce the proximal interphalangeal joint hyperflexion. The reduction was assessed by external conformation of the pastern joint. A cast was placed encompassing the foot and extending proximally to the proximal metacarpus. The cast was carefully form-fitted to the distal limb with minimal padding in an attempt to maintain reduction of the joint after recovery. Lameness did not improve after placing the cast on the limb, and the bull showed evidence of increasing lameness seven days after application of the cast. Radiographic imaging of the distal limb revealed recurrent hyperflexion of the proximal interphalangeal joints (figure 2). The cast was removed and cast-associated sores were noted overlying the dorsal aspect of the proximal interphalangeal joints. The decision was made to perform surgical arthrodesis of the pastern joints in an attempt to stabilise the bones sufficiently for the bull to be pain-free and return to normal productivity. The cast-associated wounds on the dorsal aspect of the pastern’s were medically treated until healed, and surgery was scheduled for three weeks after cast removal.

Before surgery the bull received antibiotic (ceftriaxone crystalline free acid (Excede. Zoetis), 5 mg/kg bodyweight, subcutaneously) and analgesic (flunixin meglumine, 1 mg/kg bodyweight, intravenously, once) drugs. Clinicians chose to administer ceftriaxone for the dual purpose of prophylaxis against pneumonia and bone/implant infection. This third-generation equivalent cephalosporin has excellent spectrum and sustained serum concentrations so as to provide consistent bacterial prophylaxis or treatment for up to seven days. In the authors’ experience, bulls that are transported long distances (>8 hours of trailer ride) and undergo general anaesthesia for more than three hours are at a higher risk of pneumonia after surgery as a result of the cumulative stress of transportation, gas anaesthesia and the surgical procedure. For surgery, the bull was anaesthetised and the distal limb clipped and aseptically prepared for surgery. Anaesthesia was induced by premedicating the bull with xylazine hydrochloride (0.1 mg/kg, intravenously), followed by administration of ketamine (2.5 mg/kg, intravenously) and midazolam (0.01 mg/kg, intravenously), combined and given intravenously. Once the bull was anaesthetised, an endotracheal tube was placed and general anaesthesia was maintained with isoflurane gas vapourised into 100 per cent oxygen. Biaxial incisions were
made on the dorsal aspect of both digits in the pastern region with the incision centred on the proximal interphalangeal joint and extending 10 cm proximal and 5 cm distal to the interphalangeal joint. The digital extensor tendon was split longitudinally to expose the phalanges and the joint capsule. Soft tissue dissection was extended into the PIP joint. The split tendon was reflected using Gelpi retractors, and then the joint opened with a transverse incision parallel to the joint and extending from axial to abaxial on the dorsal joint capsule. The already present hyperflexion was exaggerated and the joint was subluxated dorsally to expose the articular cartilage. A combination of hand curettes and a pneumatic osteotome were used to remove the articular cartilage. Multiple perforations of the articular surface were created to expose bleeding subchondral bone as a means to promote the ingrowth of blood vessels and osteogenic cells. The digits were then placed in tension under extension in order to reduce each pastern joint to its normal anatomical position for a standing posture. After reduction of the proximal interphalangeal joint, a 5.0-mm thick, four-hole locking plate was applied to the dorsal aspect of the first and second phalanges of each digit. Locking screws (5.0 mm in diameter) were placed in the proximal two holes of each locking plate and into the first phalanx (figure 3). A 5.0-mm diameter screw also was placed in the distal hole of both locking plates and into the second phalanx. Finally, a 5.5-mm cortical bone screw was inserted through the third hole of each locking plate and angled distally into the proximal aspect of the second phalanx (figure 4). No attempt was made to reconstruct the joint capsule; the extensor tendons were sutured with USP2 polydioxanone in an interrupted cruciate pattern, the subcutaneous layer was sutured with USP0 polydioxanone in an interrupted cruciate pattern, and the skin was sutured with USP2 polypropylene in an interrupted cruciate pattern.

A cast was placed on the limb after surgery in an attempt to protect the arthrodesis during the first 30 days after surgery. Recovery from anaesthesia and surgery was uneventful. The bull was able to stand up and place weight on the limb within four hours after discontinuation of anaesthesia. The bull returned to eating within six hours and returned to normal faecal and urine output soon afterwards.

OUTCOME AND FOLLOW-UP
The bull remained hospitalised for 14 days to evaluate the integrity and stability of the implants and to monitor for evidence of pneumonia, surgical site infection, lameness or other complications. At that time, the bull was transported back to the bull stud. Instructions were given to the referring veterinarian to remove the cast 30 days after surgery. The bull was to remain individually housed in a stall with instructions not to use it for any mounting or semen collection activities for a minimum of two months after discharge. The bull was maintained on meloxicam therapy (500 mg orally every 48 hours) for two weeks and then on an as-needed basis per the attending veterinarian’s judgement. In the USA, use of meloxicam in cattle is accepted when administered under the guidance of the Animal Medical Drug
Use Clarification Act. Two weeks after discharge, the attending veterinarian reported that the cast had been removed without difficulty and that no adverse complications were observed at the surgery site or associated with the cast. Follow-up with the veterinarian six months after surgery revealed that the bull was walking normally or with a minimal limp (ranging from grade 1 to 2 out of 5) and had been returned to normal semen collection. One year after surgery, the bull was reported to be walking sound and had returned to a normal semen collection routine.

**DISCUSSION**

Hyperflexion or luxation of the proximal interphalangeal joint is rarely reported in cattle. The first such report that the authors could find was published in 1969 and described the dislocation of the proximal interphalangeal joint in a cow. In that case, the PIP joint suffered trauma during a fall when the cow was knocked to the ground while being ridden by another cow. The cow was sedated, laid on its side, and traction was used to reduce the traumatic luxation. The cows were confined to a deeply bedded stall and returned to normal weightbearing over a period of 30 days. In the authors’ experience, the most common cause associated with hyperflexion of the proximal interphalangeal joint in cattle is excessive weightbearing as a result of injury to the contralateral limb, leading to either breakthrough injuries of the interosseous ligament (suspensory ligament), tendon of the superficial digital flexor muscle or disruption of the deep digital flexor muscle tendon. In a previous report, an adult Angus bull suffering from breakdown of the interosseous ligament characterised by severe drop of the fetlock was successfully treated with a full limb cast applied with a light flexion of the carpus and elevation of the heels for four months. Although the bull returned satisfactorily to pasture breeding, some degree of carpal flexion remained and the bull completely ankylosed the metacarpophalangeal joint. This case report of proximal interphalangeal joint hyperflexion resulting in chronic lameness, unresponsive to cast stabilisation, and ultimately responding to surgical arthrodesis of the joint biaxially represents a unique occurrence of lameness associated with hyperflexion of the proximal interphalangeal joint in an adult bull. In this particular case, the authors attributed the failure of the conservative management to the heavy weight of the bull and the chronicity of the pastern hyperflexion, most likely leading to a recurrence of the condition even during external coaptation by slow distal migration of the fetlock within the fibreglass cast. Surgical arthrodesis using biaxial application of locking compression plates has never been reported in an animal of this size and therefore represents a significant improvement in options to address chronic lameness associated with proximal interphalangeal joint hyperflexion. Short-term success has been reported for arthrodesis of the proximal interphalangeal joints in the hindlimb of 450-kg two-year-old Braunvieh heifer. This heifer suffered traumatic luxation of the second phalanx of the medial digit of the right hindlimb. Concurrent hyperflexion of the second phalanx of the lateral digit also was present. The authors were able to perform closed reduction of the luxations followed by surgical arthrodesis. Arthrodesis was achieved using a narrow 4.5-mm, three-hole equine locking plate, one each applied to each joint. The authors reported that placement of the bone plates resulted in stable arthrodesis of the proximal interphalangeal joints, but lameness persisted. After having a calf, the heifer was slaughtered eight months after surgery because of varus deformity that had developed in the contralateral limb as a result of chronic altered weightbearing. Postmortem radiographic imaging revealed only partial bridging of the joint. The outcome of this effort was considered partially successful because it was able to deliver a calf after surgery; however, it had to be culled as a result of lameness complications originating from the original disease. Outcomes with the adult bull reported here suggest that arthrodesis of the PIP joints in cattle can be achieved successfully. However, health and soundness of the other limbs may be key to a successful recovery and a good long-term prognosis.

Finally, international standards and regulations regarding drug use in food animals are variable. The reader needs to interpret this report within the context of decisions (antibiotics, anti-inflammatory drugs, anaesthetic drugs) made using guidelines in the USA. Veterinarians managing similar cases would have to make choices consistent with the applicable regulations and guidelines within their region.

**Contributors**

All authors contributed to the successful management of this case. DEA, P-YM and RTS performed the surgery. P-YM and RV performed case management and made clinical decisions regarding treatment of comorbidities. P-YM and DEA reviewed case medical records to ensure accuracy of information. All authors contributed to the writing and editing of this case report.

**Funding**

The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests**

None declared.

**Provenance and peer review**

Not commissioned; externally peer reviewed.

**Data availability statement**

No additional data are available.

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