Treatment of Fractures and Tendon Injuries in the Field: External Coaptation in the 21st Century!

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Introduction

Perhaps more than any other industry for which veterinarians are asked to provide service, the decisions made for treatment of food animal patients is based on return on investment rather than optimum fracture treatment. For example, there are several appropriate methods for treatment of a closed, minimally comminuted, short oblique, mid-diaphyseal tibia fracture in a 660 lb (300 kg) cow. These include Thomas splint-cast combination, transfixation pinning and casting, and bone plating. What treatment will you chose? Most often the owner is given 2, or perhaps 3, choices based on the familiarity and expertise of the clinician with each of these treatment techniques. All of these treatment techniques are appropriate and successful when applied well, but each differs in the complications that may occur.

Fractures involving the limbs are common in farm animals, are most commonly found in young stock, and often occur subsequent to trauma during dystocia. The most common fractures diagnosed in food animals include metacarpus and metatarsus (~50%), tibia (~12%), radius and ulna (~7%), femur (<5%), humerus (<5%), pelvis (<5%), and phalanges (<1%). Occasionally, fractures of the axial skeleton (mandible, vertebra, ribs, pelvis) are found. Food animals are considered to be excellent patients for treatment of orthopedic injuries because they spend a majority of time lying down, have a tremendous osteogenic potential, are more resistant to contralateral limb breakdown and stress laminitis, and usually do not resist having orthopedic appliances on their limbs. The decision to treat a fracture in a food animal is made by considering the cost of the treatment, the success rate of the treatment, the perceived or potential economic or genetic value of the animal, and the location and type of fracture. Most owners will elect to pursue inexpensive treatment for fractures with a high success rate, but owners also often elect to pursue costly fracture treatment despite poor success rates when cattle are perceived to have high economic or genetic potential.

Emergency Treatment and First Aid

A thorough physical examination should be conducted on all animals suspected of having a fracture prior to the decision for treatment. However, the patient first must be made safe from continued trauma. Often, injured cattle are recumbent when examined. The animal should be allowed to remain recumbent until the physical examination has been conducted and an initial fracture assessment done. Assessment of the hydration, cardiopulmonary, and shock status is of utmost importance. Young calves may suffer life-threatening hemorrhage after femur fracture if the femoral artery has been lacerated. Multiple rib fractures may be life-threatening if they cause flail chest, pneumothorax, or hemothorax. Adequate passive antibody transfer to newborn calves is critical to pre-operative preparation of the patient and success of the procedure. If colostrum ingestion is unknown, serum immunoglobulins should be determined or total protein measured. Calves that are well hydrated and have a serum protein of less than 5.5 g/dl should be considered to have poor colostral antibody transfer and receive a plasma transfusion before attempting fracture repair.

Temporary stabilization of limb fractures may be performed prior to moving the animal or attempting to get the animal to stand. As a general rule, fractures below the level of the mid-radius or mid-tibia may be temporarily stabilized with splints or casts. Field stabilization of fractures proximal to this level should not be attempted. These efforts often result in the creation of a "fulcrum effect" at the fracture site and result in increased soft tissue trauma, damage to neurovascular structures, or compounding of the fracture. Cattle with these fractures should be carefully loaded into the trailer and allowed time to lay down before beginning transport. For these proximal injuries, cattle will protect the limb adequately for transport and any additional trauma that occurs is less severe than that which may occur as a result of the "fulcrum effect".

External coaptation for temporary stabilization of the fracture may be done by using two splints or a cast.

Two boards or pieces of a large PVC pipe cut in half, placed 90 degrees to each other (e.g., caudal and lateral aspect of the limb), create a stable external coaptation. A padded bandage is placed on the limb, the splints positioned and elastic tape applied firmly. Circular clamps (e.g., hose clamps) may be used to achieve firm placement of the splints on the limb. The injury should be centered within the coaptation with as much support proximal and distal to the injury as possible. All external coaptation devices should extend to the ground (to a level immediately distal to the sole of the hooves). For injuries distal to the carpus or hock, the splints should be placed to the level of the proximal radius or tibia, respectively. For injuries proximal to the carpus or hock and distal to the mid-radius or mid-tibia, the lateral splint should extend to the level of the proximal scapula or pelvis, respectively.

Principles of Fracture Management

The location of the fracture, presence of soft tissue and neurovascular trauma, closed or open fracture environment, behavioral nature of the animal, and experience of the veterinarian are important factors for considering what type of treatment is chosen. Fractures of the axial skeleton are often treated by stall rest alone, because external or internal fixation is not required. For fractures involving the apendicular skeleton, the following questions must be answered: 1) is treatment required, 2) can the fracture be acceptably reduced closed or is internal reduction required, 3) can the fracture be adequately immobilized using external coaptation alone, or is internal fixation, with or without external coaptation, required, 4) and what is the cost-benefit analysis.

Walking Block for Bovine Digit

Cattle have two weightbearing digits for each limb, and therefore, may stand on one digit during convalescence of the paired digit (e.g., phalangeal fracture). A wooden, rubber, or plastic block (2.5 to 5.0 cm height and formed to the size and shape of the healthy hoof) can be applied to the sole of the healthy digit. The animal is confined to a stall or small pen for 6 to 10 weeks while fracture healing proceeds and the block is removed. Often, wooden blocks will become worn and removal is not necessary.

Casting

Half-limb casts (short casts) can be used for immobilization of phalangeal fracture and for distal metacarpal or metatarsal physis fracture. The cast is placed from a point immediately distal to the carpus or hock extending to the ground and encasing the foot. The dew claws and the top of the cast are padded, but only stockinet or foam resin padding (3M Custom Support Foam, 3M Animal Care Products, St-Paul, MN) is placed on the remainder of the limb. Thick padding, placed along the entire limb, will quickly become compressed leaving room for the limb to move within the cast and displacement of the fracture to occur. Full-limb casts are used for fractures occurring at or proximal to the mid-metacarpus or metatarsus, but distal to the mid-radius or mid-tibia. Full limb casts are placed similarly to half limb casts, but the bony prominence of the accessory carpal bone, styloid process of the ulna, calcaneous, and medial and lateral maleolus of the tibia must be padded.

Placement of the cast is facilitated by use of rope restraint, sedation, or anesthesia as needed. An assistant should help to maintain alignment of the limb during application, being sure to check the position of the limb in cranial to caudal and lateral to medial planes. Tension on the limb during casting may be achieved by placing wires through holes drilled in the hoof wall and applying tension. The holes should be placed such that the hoof is positioned in a normal to slightly flexed position. The thickness of the cast is usually based on clinical judgement. Casts 6 to 8 layers thick may be adequate for calves less than 330 lb (150 kg) body weight, but adult cattle may require casts 12 to 16 layers thick. Casts used on the hind limbs must be made thicker because of stress concentration by the angulation of the hock. Incorporation of metal rods within the cast (two rods placed 90 degrees to each other) can increase the strength of the cast, but is only needed in the largest of patients. Newer fiberglass casting materials are more resistant to breaking and do not weaken when wet if sufficient cast material is used compared with plaster of Paris casting materials. Use of a walking bar ("U" shaped bar placed under the hoof and incorporated into the cast) will increase distribution of loading forces into the cast and away from the distal limb, but the foot should always be included in the cast.

Casts may be maintained in calves for up to 6 weeks without being changed. Scheduled cast changes at 3 week intervals may be required for rapidly growing calves or for calves that become lame during convalescence. Physeal fractures are usually healed within 4 weeks, but non-physeal fractures often require 6 weeks to reach clinical union in calves. Fractures in adult cattle often heal within 8 to 10 weeks, but may require 12 to 16 weeks for clinical union to occur. Radiographic union of the fracture (defined as bone union with resolution of the fracture line) is not seen for weeks to months after clinical union (defined as sufficient bridging callus to allow weight bearing without additional support to the limb) has been reached.

Thomas Splint and Cast Combination

Use of a Thomas splint and cast combination is appropriate for fractures proximal to the mid-radius and mid-tibia, but distal to the elbow or stifle. The length of the splint should be measured while the animal is standing and by using the normal limb for measurements. An appropriate splint is chosen or constructed, and the patient is placed into lateral recumbency (rope restraint, sedation, and / or anesthesia). The fracture is reduced and a cast applied from the distal metacarpus or metatarsus to the level of the proximal radius or tibia. The splint is placed on the limb, the foot is attached to the base of the splint by drilling holes in the hoof walls and wiring the foot to the splint base, and casting tape is used to attach the cast to the splint frame. The limb cast should be firmly attached to the splint frame to prevent rotation of the limb along the splint during ambulation. The hoop of the splint must be firmly placed into the axilla or groin to allow maximal weigh transference and, therefore, the hoop must be heavily padded. Cattle having a Thomas splint-cast should be assisted to stand for 3 to 5 days until they learn how to rise under their own power. Also, these patients must be checked several times daily to ensure that they have not laid down on top of the splint. Often patients are not able to rise after lying down on the splint and life-threatening rumen tympanities may occur if they remain trapped for a prolonged period.

Thomas splint-cast combinations are best used in cattle less than 660 lb (300 kg) and is very economical ($200.00 +). Our success rate for bone healing is > 90% with these light-weight animals. Our success rate in adult cattle has been approximately 60%. However, complications include contralateral limb tarsal varus and tendon breakdown, cast and splint ulcers, mal-alignment or malunion of the fracture, opening of the fracture with development of osteomyelitis or bone sequestra, chronic recumbency during convalescence, and persistent lameness. See Tables 1-4 for case management details.

Metacarpus / Metatarsus III/IV

The most common fracture of the MC or MT is injury to the distal physis (almost always Salter-Harris I or II). These injuries usually occur as the result of traumatic manual extraction of calves because of dystocia. Also, the fractures are nearly always closed and respond to casting with an excellent prognosis (>95%) provided that the blood supply to the limb has not been damaged. Occasionally, forced manual extraction results in the creation of an open wound or skin sloughing occurs because of damage to regional blood supply. MC or MT fractures also are seen following trauma from calves being stepped-on or from fighting among cattle. The prognosis for closed MC or MT fractures is inversely related to age and body weight and is directly related to fracture configuration. Half-limb casts may be used for distal physeal fractures, but full-limb casts should be used for all fractures proximal to the distal metaphysis (especially in older cattle). Calves usually require 4 to 6 weeks of external coaptation. Adult cattle usually require 8 to 10 weeks of external coaptation. Transfixation pinning and casting, bone plating, or Thomas splinting and casting should be considered for comminuted or long oblique fractures because these injuries have little inherent stability and carry a higher risk of becoming open within a cast.

Table 1. Age and weight distribution among survivor and non-survivor cattle affected with tibial fracture stabilized with Thomas splint cast combination.

Variable	Survivors N	Non-Survivors N
Age		
< 6 months	10	0
6 mo. to 1 year	4	0
1 to 2 years	2	3
> 2 years	1	1
Weight		
< 455 kg	9	0
> 455 kg	5	3

Adapted from: Anderson DE *et al* Agri-Practice 15:16-23, 1994.

Table 2. Radiographic findings in 21 cattle with fractures of the tibia repaired with a Thomas splint-cast combination.

Fracture configuration	Number of cattle
Severely comminuted diaphysis	6
Long oblique, diaphyseal	
comminuted	6
simple	2
spiral	2
Salter-Harris II	
proximal physis	3
distal physis	2

Adapted from: Anderson DE *et al* Agri-Practice 15:16-23, 1994.

Table 3. Complications observed with a Thomas splint-cast combination to repair tibial fracture.

Complication	Number affected	Number resolved
Pressure sores	9	9
Closed fracture becoming open	3	1
Chronic recumbency	3	1
Distal physeal fracture, metatarsus	2	2
Delayed union	2	2
Disuse osteoporosis	2	2
Fetlock varus, contralateral limb	2	1
Gastrocnemius muscle contracture	1	1
Chronic lameness (follow-up N=15)		
mild	3(20%)	
moderate	3(20%)	

Adapted from: Anderson DE *et al* Agri-Practice 15:16-23, 1994.

Table 4. Potential costs involved in Thomas splint-cast management of tibial fracture in cattle when splints have been pre-made and are available.

Item	Calf	Adult
Radiographs	$ 60.00	$ 80.00
Sedation	$ 5.00	$ 10.00
Casting Material	$ 65.00	$125.00
Reusable Splint (use fee)	$ 25.00	$ 50.00
Antibiotics	$ 10.00	$ 25.00
Professional fee	$ 60.00	$120.00
Total	$225.00	$410.00

Adapted from: Anderson DE *et al* Agri-Practice 15:16-23, 1994.

Tibia

Tibia fractures most commonly occur as a result of fighting or breeding trauma. Occasionally, the proximal or distal physis of the tibia may be injured during dystocia, but these injuries more often result from trauma. Full-limb casting is appropriate for S-H I fractures of the distal physis, but fractures proximal to the distal diaphysis require more stable repair methods. Although Thomas splinting and casting can be used successfully, complications resulting from this form of stabilization can be detrimental (open fracture, malunion, delayed union, gastrocnemius contracture, contralateral limb varus deformity or tendon breakdown). Bone plating of the tibia is relatively straight forward. A craniomedial approach is made and two plates are applied to the tibia (1 craniomedial and 1 craniodorsal). Use of bone plates provides accurate anatomic reconstruction of the tibia, superior cosmetic healing, and may minimize the convalescent period. Transfixation pinning and casting (TPC) is the mainstay for stabilization of tibia fracture in our practice. TPC is a rapid, less expensive method of fracture repair, requires minimal equipment and capital investment, and provides a prognosis equal to that achieved by bone plating. However, TPC does not provide anatomic reconstruction of the bone and, therefore, convalescence may be 12 to 16 weeks for clinical union of the bone. Also, potential complications include contralateral limb defects (varus, tendon laxity) and pin tract morbidity.

Femur

ESF alone is not sufficient for management of femur fractures. However, ESF in Type I configuration is useful to preserve limb length after intramedullary pinning when comminution of the femoral diaphysis results in instability. Invariably, pins will be placed in a staggered configuration and, therefore, flexible tubing and construction of an acrylic sidebar is useful. Although bends in the acrylic sidebar may weaken the stiffness of the assembly, I have not found this to be clinically significant. I usually remove the Type I fixator 30 days after surgery and remove the intramedullary pins, if possible, after 60 days.

Radius/Ulna

The radius is ideally suited for external skeletal fixation appliances. The radius has relatively little soft tissue surrounding the bone, is fairly straight in geometry, and the bone is accessible around its entire circumference. Most radius fractures occur in the middle to proximal diaphysis, are comminuted, and are closed. Distal diaphyseal fractures may present a challenge for ESF, but I have had good clinical success with transarticular ESF. These animals tend to drag the limb when ambulating, but do use the limb to stand. Six to 10 weeks of convalescence is expected.

Tendon Injuries in Cattle

Tendon injuries in cattle can be classified as congenital, developmental, or acquired. Tendon injuries are common in cattle, but are frequently overlooked as part of a more severe disease complex. Most congenital and developmental defects occur as tendon contraction. Acquired tendon injury occurs as tendon **disruption or tendon sheath infection.**

***Contracted** tendons*

Contracted tendons may be present at birth or develop in rapidly growing calves. Congenital tendon contracture may be caused by malpositioning of the calf in the uterus, ingestion of toxins by the cow during early gestation (e.g., ingestion of lupine plants between 40 and 70 days gestation), be associated with arthrogryposis caused by *in utero* infection with Akabane virus or Bluetongue virus, or by an inherited disorder (arthrogryposis and cleft palate of Charolais cattle, simple autosomal recessive gene). Contracted tendons caused by toxins, viral infection, or inherited disorders are usually severe, associated with arthrogryposis, and have a poor prognosis for correction and survival. Affected calves are usually euthanatized. When treatment is attempted, tenotomy of the superficial and deep digital flexor tendons in addition to transection of the caudal and palmar joint capsules of the carpus and fetlock, respectively, may be required to straighten the limb. If this is done, splinting or casting of the limb for 4 to 8 weeks may be required to allow the flexor tendons to heal. Contracted tendons caused by malpositioning in the uterus of calves usually is seen in large birth weight calves with rapid growth rates. For flexor tendon contracture in which the sole of the foot does not come into contact with the ground, physical therapy and splinting or casting are indicated. Casting, alone, is only indicated for calves in which the limb can be straightened and held in a near normal conformation. For calves in which the limb cannot be straightened, daily physical therapy in addition to splinting of the limb usually will effect a cure. Constant splinting of the limb for 2 to 4 days followed by a regimen of 12 hours splinting and 12 hours off, during which forced exercise and physical therapy are done for 5 to 7 days, may be used. Physical therapy is done by forcibly extending the limb to the maximum allowable extent for 20 to 40 cycles over a 10 to 15 minute period done two to three times during the 12 hours that the splint is off. If sufficient improvement is not observed after 7 to 10 days, then tenotomy of the most severely affected flexor tendon should be considered. Once the limb has been corrected to a near normal conformation, forced exercise is needed to complete rehabilitation. Placement of extended toe splints on the hoofs will increase tension on the flexor tendons during ambulation. Toe splints are easily applied by using hoof acrylic to form an extension onto the hoof wall at the toe. These extensions will usually remain in place two to three weeks, at which time the calf should no longer require assistance. Administration of non-steroidal anti-inflammatory drugs will provide analgesia and increase voluntary exercise. Developmental contracted tendons usually occur in 6 to 10 month old show calves when they are being fed for maximal growth. Affected calves are usually presented with a complaint of "standing on the toes". These calves have an upright or slightly flexed joint posture at the fetlock, but the dorsal one-third of the sole still contacts the ground. Extended toe splints, forced exercise, and limitation of concentrate feeding will usually effect a cure. Application of a half limb cast after forced extension of the fetlock can be used for 3 to 4 weeks.

Tendon laceration and disruption

Tendon laceration occurs most commonly in adult, female, dairy breed cattle. These injuries are usually caused by accidents with farm machinery (72%) and multiple flexor tendons most often are involved (70%). An open wound almost always is present and injury most commonly occurs at the proximal or mid-metatarsus. The tendons of affected cattle should be immobilized as soon as possible to prevent further injury to the neurovascular structures of the distal limb. The wound should be cleaned, debrided, and the tendons inspected. If the laceration involves the flexor tendons of a single digit, treatment may be done using a wooden claw block attached to the sole of the healthy digit. If the flexor tendons of both digits are involved, then external coaptation, with or without tenorrhaphy, is indicated. In one retrospective study, outcome was not improved by the use of tenorrhaphy. External coaptation is needed for approximately 10 weeks (74 $\pm$ 34 days), with an additional 2 weeks of confinement (total convalescence of 88 $\pm$ 60 days). The prognosis for return to productivity (87%) and long-term productivity (73%) is good. Long-term complications include persistent lameness (56%) and hyperextension of the digits (19%).

Tendon disruption may occur secondary to sepsis and tendon necrosis. The deep digital flexor tendon is most commonly involved because of avulsion from the third phalanx as an extension of the sole ulcer complex. Treatment is performed by debridement and cleaning of the wound and providing support for the tendon. Tendon repair by fibroplasia will occur if the initiating disease is resolved.

Tenosynovitis

Tenosynovitis most commonly involves the digital flexor tendon sheath, is caused by a laceration or puncture wound, and is septic. Affected cattle are not weight bearing or bear minimal weight on the limb. Distention of the flexor tendon sheath is noted by swelling immediately proximal to the dew claws. Synovial fluid analysis is diagnostic (NCC > 50,000 cells/µl; TP > 5.0 g/dl). Surgical debridement and implantation of a drain within the sheath for 5 to 7 days is the treatment of choice. Antibiotics should be administered for 14 to 21 days. The prognosis for return to productivity is good when intensive treatment is initiated early in the progression of the disease. If flexor tendon disruption has occurred, the prognosis is poor.

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