Condylar fractures in horses —a review

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INTRODUCTION

Fractures of the third metacarpal (MCIII) or third metatarsal (MTIII) bones are the most common long bone fractures in horses, with fractures of the lateral and medial condyles composing the majority of long bone fractures in racehorses in-training.[1] In thoroughbred (TB) racehorses, MCIII fractures are twice as likely to occur as MTIII fractures, with an equal distribution between left and right limbs.[2] The medial condyle is larger and fractures less commonly, composing only 5-35% of all condylar fractures, in spite of carrying a greater load.[1, 3-6]
In a recent study of 174 condylar fractures in 167 TB racehorses in the United Kingdom, 79.9% were lateral, with the remaining 20.1% occurring medially.[7] In the United States, condylar fractures accounted for 25% of horses euthanised at racetracks.[6]

ANATOMY

The macroscopic and microscopic structure of the distal epiphysis and metaphysis of MC/MTIII are comparable. The distal epiphysis consists of the lateral and medial condyles that are separated by a sagittal ridge angled laterally. The medial condyle is the larger of the two condyles in both the mediolateral and dorso-palmar/plantar planes. The medial condyle has a flat distal articular margin, unlike the lateral condyle which has a slight proximal axial incline. Additionally, the palmar/plantar articular surfaces of the condyles at their articulation with the proximal sesamoid bones are flatter compared to the dorsal articular surfaces articulating with the proximal phalanx. Immediately adjacent to the sagittal ridge are the medial and lateral parasagittal/condylar grooves which appear as inconsistent indentations between horses.[7]

AETIOPATHOGENESIS OF CONDYLAR FRACTURES

The exact aetiopathogenesis of condylar (parasagittal) fractures has yet to be elucidated, however, several consistent observations have been made:

1. Structural failure of the condyle typically occurs during high speed exercise[6], and occurs more commonly in horses in-training than during racing;[8]
2. Fractures tend to be ‘spontaneous’ in nature and are not preceded by a traumatic event;[9]
3. Fractures occur in a predictable location; [10,11] and,
4. Fracture occurs in a region of adapted bone with pathologic changes.[9-11]

Bone fractures occur under two main circumstances;

1. FRACTURE UNDER SUPRAPHYSIOLOGIC LOADS

When a bone is placed under a force such that the magnitude of the stress exceeds the ultimate failure point of that bone, the bone fractures. This type of fracture is usually a high-energy, single, traumatic event, such as a kick or fall, and is not a common cause of condylar fractures in horses.

2. FRACTURE UNDER NORMAL PHYSIOLOGIC LOADS

Pathologic Fracture

This type of fracture occurs when a bone is weakened by a disease process such as infection, osteoporosis, neoplasia, bone fragility syndrome or a metabolic disorder. This weakened bone can then fracture under normal physiological loads. This is an uncommon cause of fracture in the horse.

Repetitive Strain Injury

This is the main mechanism by which condylar fractures occur in horses, and has been the subject of extensive research. During high-speed exercise, large loads are transmitted through MC/MTIII, resulting in deformation of the bone beyond its yield point and subsequent inflammation. This inflammation causes apoptosis of osteocytes and loss of homeostasis of the bone matrix. Consequently, the bone becomes hypermineralised (>66% mineral) and, therefore, stiffer. Bone is inherently a stiff structure, with low strain tolerance to rupture (~4% in

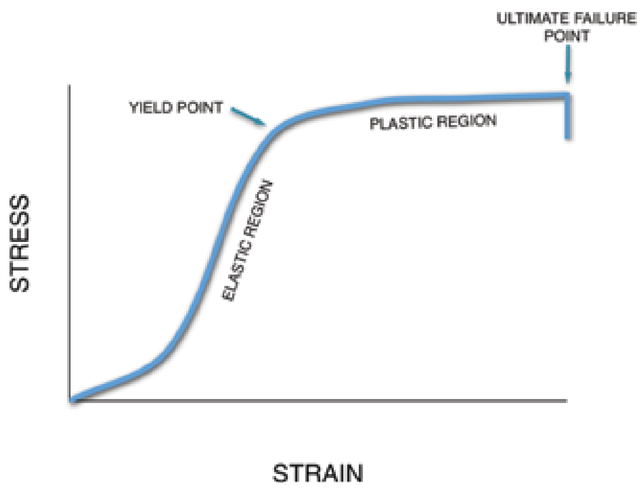

Figure 1: Stress-strain curve of a bone undergoing compression. If the bone is loaded beyond the yield point permanent deformation (fracture) will occur.

cortical bone and 5% in cancellous bone). Any increase in bone stiffness decreases tolerance to rupture, and can result in brittle fractures known as microfractures (Figure 1). These microfractures further compromise the structural integrity of bone.

Under normal circumstances the co-ordinated action of osteoclasts and osteoblasts allows bone to adapt by the processes of modeling (where bone is removed from and added to different places) and remodeling (where bone is removed from and added to the same place). Optimally, the rate of microfracture equals the rate of bone repair, and the horse suffers no ill effects. However, when cyclical high loads are experienced over time, the balance may be shifted away from bone repair and in favour of microfracture formation as remodeling is inhibited by the high-strain environment. As microfractures accumulate, they may coalesce such that the structural integrity of the bone becomes compromised and the bone fails under normal physiological loads. This manifests as a macrofracture that we recognise on a radiograph as a condylar fracture.

Typically, this process is most severe at the palmar/plantar aspects of the distal epiphysis of MC/MTIII at their articulation with the proximal sesamoid bones. Condylar fractures typically begin at the articular surface at this point, propagating proximally in the sagittal plane.[12]

FRACTURE CONFIGURATIONS

A wide variety of fracture configurations have been documented. Lateral condylar fractures may uncommonly be unicortical, involving only the palmar/plantar cortex (Figure 2), however, the vast majority are bicortical. Approximately 60% initiate within the sagittal ridge or

Fig 2: Unicortical fracture of the palmar lateral cortex of the right MCIII. Lateral is to the left of the image.

parasagittal groove, with the remaining 40% initiating abaxial to this, in the center of the lateral condyle. Lateral condylar fractures predictably propagate vertically and abaxially with a consistent configuration. The majority exit the lateral cortex 6-8cm proximal to the distal physeal scar. The more abaxial the fracture, the shorter it tends to be.[7]

If the fracture does not extend the entire way to the lateral cortex it is termed an incomplete lateral condylar fracture (Figure 3). Conversely, if the lateral cortex is breached it is a complete lateral condylar fracture (Figure 4) however, this distinction is often difficult to determine radiographically.

Figure 3: Incomplete lateral condylar fracture of the right MCIII. This radiograph was obtained from the same horse as in Figure 2 five weeks later. Non-compliance by the trainer in regard to the prescribed rest and rehabilitation program resulted in this horse fracturing during a race.

Figure 4: Non-displaced complete lateral condylar fracture of the right MTIII.

Approximately three-quarters of complete lateral condylar fractures develop some degree of displacement (Figure 5). In a study of displaced condylar fractures, all showed evidence of palmar/plantar comminution on computed

Figure 5: A. Non-displaced lateral condylar fracture of the left hind MTIII two hours following the onset of lameness. This horse was treated conservatively at the owner's request. B. Displaced lateral condylar fracture of the left hind MTIII of the same horse 10 days later. This horse had been noted to lie down several times.

Figure 6: Spiralling lateral condylar fracture of the right MCIII treated with cortical bone screws and a laterally positioned dynamic compression plate.

Figure 7: Spiralling medial condylar fracture of the left MCIII. Medial is to the right of the image.

Figure 8: Full-limb cast applied to the right hind limb of a horse with a medial condylar fracture that was treated conservatively.

tomography (CT) while only 58% had radiographic evidence of comminution,[12] with older radiographic studies reporting comminution in 27-55% of all lateral condylar fractures.[13-15] Rarely, a lateral condylar fracture which propagates axially will occur. This is important as they are treated in a manner similar to medial condylar fractures (Figure 6).
The majority of medial condylar fractures initiate within the parasagittal groove and propagate axially towards the proximal metaphysis of MC/MTIII, with 73% demonstrating a spiralling component[16] (Figure 7). The remainder have a sagittal course to the mid-diaphysis, where they may form an occult 'Y' configuration.

CLINICAL SIGNS AND DIAGNOSIS

Identification of horses with complete or displaced lateral condylar fractures or medial condylar fractures is generally straightforward. Horses with short, incomplete fractures or those at the pre-fracture stage may present more of a diagnostic challenge for the clinician.
Typically horses have a history of several bouts of lameness in the preceding weeks to months, which may or may not have been localised to the metacarpo/tarsophalyngeal (MCP/MTP) joint. The lameness will usually have blocked out to either a low-4-point or low-6-point nerve block.
Overt fracture generally occurs during high-speed training or racing. Horses usually display an acute lameness which may not be evident for 10-15 minutes after cessation of activity due to the high levels of circulating cortisol. There is almost always haemorrhagic effusion of the MCP/MTP joint, with resentment of palpation and flexion of the associated region. Over the first 24 hours, some non-displaced lateral condylar fractures and all displaced lateral condylar fractures develop obvious swelling on the distal and lateral aspect of MC/MTIII. With displaced condylar fractures, the spiked metaphyseal component of the fracture may be palpable subcutaneously. Occasionally crepitus may be appreciated on flexion and extension of the MCP/MTP joints.
Counter-intuitively, many non-displaced fractures initially display a greater degree of lameness than displaced fractures. This occurs because the intact periosteum of the lateral cortex has a high density of sensory neurons which are continuously stimulated by the unstable non-displaced fracture. Conversely, with displaced condylar fractures the periosteum is completely disrupted at the time of the fracture and, therefore, further stimulation does not occur.
Medial condylar fractures typically present with acute severe lameness due to the extent of the long fracture lines. There may be resentment to flexion and extension of the MCP/MTP joints, however, there is typically no appreciable soft-tissue swelling.
If there is a suspicion of any type of condylar fracture, both regional and intra-articular anaesthesia are strictly contraindicated due to the high risk of fracture propagation and catastrophic bone failure.
Classically condylar fractures have been ascribed to one of four groups:[17]

1. Type I – incomplete, propagate for a variable distance.
2. Type II – complete, non-displaced.
3. Type III – complete, displaced.
4. Type IV – longitudinal or diaphyseal fractures involving the medial condyle.

Additionally, longitudinal or diaphyseal fractures involving the lateral condyle are also recognised.
Good quality radiographs of the MCP/MTP joint are generally diagnostic. In cases of medial condylar fractures, a full series of radiographs of the entire length of MC/MTIII is also warranted. The standard series of radiographic projections of the MCP/MTP joint includes the following:

- Dorsal 15° proximal-palmaro/plantaro distal oblique.
- Lateromedial.
- Dorsal 45° lateral – palmaro/plantaro medial oblique.
- Dorsal 45° medial – palmaro/plantaro lateral oblique.

From the surgeon's point-of-view, there are several additional views of particular use. These include a dorsal 5° lateral-palmaro/plantaro medial oblique and a dorsal 5° medial-palmaro/plantaro lateral oblique. These additional views allow the surgeon to determine the direction of spiralling of the fracture, facilitating placement of the more proximal screws in lag fashion. A dorsal 35° proximal-palmaro/plantaro distal oblique projection with the MC/MTIII held in a vertical orientation is often very helpful for identification unicortical fractures and fractures with palmar/plantar comminution which are not easily identified on a standard dorsal 15° proximal-palmaro/plantaro distal oblique. This is important as unicortical fractures may easily be treated conservatively, and the presence of palmar/plantar comminution may affect the prognosis. This view allows us to recognise palmar/plantar comminution in the 60% of cases in which it is present.[12]
In recent years the use of scintigraphy, magnetic resonance imaging (MRI) and CT have greatly aided in identifying the prodromal characteristics of condylar fractures. Of these imaging modalities, transverse CT sequences are considered to provide the surgeon with the greatest information due to the rapid acquisition of images and ability to identify palmar/plantar comminution.

FIRST AID

With the availability of portable digital radiography systems, many fractures are currently diagnosed either on the farm or at the racetrack. Until a definitive course of treatment is decided upon, the fracture must be stabilised so that any further propagation of the fracture is minimised. Many horses are distressed, particularly those with medial condylar fractures. Sedation may be necessary, however, care must be taken to use the lowest possible dose such that that horse does not become uncoordinated or place undue weight upon the injured limb. A non-steroidal anti-inflammatory drug may be administered in the case of severe pain, however, this is generally not necessary for condylar fractures, particularly if the horse is to be transferred to a referral facility.
With lateral condylar fractures, a half-limb Robert Jones bandage consisting of multiple layers, each tighter than the previous, is usually sufficient for initial stabilisation and transportation. Medial condylar fractures should have at the least a full-limb Robert Jones bandage for initial stabilisation and transportation. If the fracture is determined to be of a particularly high risk of catastrophic failure a full limb cast should be immediately applied (Figure 8). All horses with condylar fractures, and particularly those with medial condylar fractures, should be prevented from lying down as any attempt to stand may result in fracture displacement with catastrophic consequences. This pertains especially to hindlimb medial condylar fractures. If the horse is to be transported the driver must be instructed to drive slowly, with particular attention paid to gentle breaking and accelerating so that the injured leg is not forced to support and balance the horse. If in doubt, the specialist at the referral facility should be contacted for advice.

TREATMENT

Lateral Condylar Fractures

Unicortical condylar fractures of the palmar/plantar condylar cortex may successfully be treated conservatively with rest, as this type of fracture has a very stable configuration. A walking program should begin as soon as the horse is sound at a walk, and follow-up radiographs obtained every four weeks until healing is completed.
Unfortunately few condylar fractures are identified at this early stage. This may be due to a failure to identify the early clinical signs of condylar pain, failure to obtain the specific radiographic projections or the lesion being radiographically-silent at the time the image is obtained.
Incomplete lateral condylar fractures have traditionally been treated conservatively with rest and a graduated rehabilitation program, with serial radiographic monitoring. This results in fracture repair by secondary bone healing. Micromotion between the fracture ends creates strain which is greater than that tolerated by normal cortical bone (>4%). If new bone is laid down under these circumstances it would simply crack, therefore, the fracture gap is filled with granulation tissue that has a much larger tolerance to strain (up to 100%). This granulation tissue gradually begins to stabilise the fracture, reducing strain and allowing a cartilaginous callus to form, which further reduces strain. This later becomes calcified to unify the fracture ends. It is important to note that smaller fractures, which typically are the type treated conservatively, actually experience greater strain than larger fractures. Therefore, the body initially enlarges the fracture gap to decrease the strain and allow secondary bone healing to progress. Radiographically, this appears as widening of the fracture gap over the initial few weeks, and it should not be misidentified as failure of the fracture to heal or displacement, rather simply a normal physiologic response of the bone to strain.
Although conservative therapy is usually

Figure 9: Incomplete lateral condylar fracture of the right MCIII that was repaired using two 4.5 mm cortical bone screws placed in lag fashion. This is the same horse as in Figures 2 & 3. Lateral is to the left of the image.

Figure 10: Disarticulated right metatarsophalangeal joint two days following a spiralling medial condylar fracture. Note the severe bruising to the proximal sesamoid bones, MTIII and proximal phalanx. Medial is to the right of the image.

effective in the long term, the optimal treatment for more rapid return to function and reliable bone healing is surgical fixation. Surgical treatment often ultimately ends up being less costly than conservative treatment, as the fracture heals faster and the horse can return to training and racing sooner. Additionally, surgical fixation prevents the horse from re-fracturing in this region in the future. Fixation is achieved with the use of cortical bone screws placed in lag fashion in the lateral-to-medial plane, stabilising and compressing the fracture. It was traditionally believed that this facilitated primary bone healing, however, even with the most rigid form of internal fixation it is currently considered unlikely primary bone healing can occur in horses. This is due to residual micromotion which results in interfragmentary strain >2%, necessitating secondary bone healing.

Non-displaced lateral condylar fractures can be repaired either under general anaesthesia or in the standing, sedated horse with the use of peri-neural regional anaesthesia.[18] Typically two cortical screws applied in lag fashion are sufficient for the majority of lateral condylar fractures (Figure 9). The most distal screw is placed in the epicondylar fossa. This screw is positioned in the palmar/plantar half of the condyle, in the area where the fracture initiates. If this first screw is placed too proximally, there is a risk of re-fracture distal to the screw. My preference is to use 4.5mm cortical bone screws, with others reporting the use of 5.5mm cortical bone screws. Some authors report the use of up to three screws in a triangular fashion in the epicondylar fossa, however, this is probably unnecessary, especially in the case of non-displaced lateral condylar fractures. In the uncommon instance that the bone threads for a 4.5mm cortical bone screw are stripped, a 4.5mm cortical screw may be replaced with a 5.5mm cortical bone screw. The second screw is placed in a similar fashion 15-20mm proximal to the first, at approximately the level of the physeal scar. Unless the fracture is excessively long no further screws are required, provided the first two are placed correctly. This also avoids the risk of splitting the proximal metaphyseal spike of the fracture fragment. Horses can usually be recovered from general anaesthesia in a full-limb Robert Jones bandage.

If only two screws are required, they are not removed routinely. Occasionally, a third or fourth screw is required for treatment of a long fracture or one which takes a more axial course. A fourth screw usually needs to be removed once the fracture is healed if the horse is intended for racing, as it will act as a stress riser and will cause pain and lameness at high speeds. The third screw is generally removed at the same time. If only three screws were initially implanted, the third screw is not removed routinely unless it is thought to be causing pain. It is not uncommon for horses to remain lame after removal of a third screw because the source of lameness is generally osteoarthritis in the MCP/MCT joint rather than from the screw itself. For this reason care should be taken to rule out MCP/MCT joint osteoarthritis and all other sources of pain before the third or even second screw is removed.

Displaced lateral condylar fractures should be surgically repaired under general anaesthesia. Near perfect anatomical reduction is required if the horse is to have any chance of an athletic career as the MCP/MCT joint is a high motion and heavily-loaded joint.[15] This is achieved with the use of intra-operative arthroscopic visualisation.[19] Due to the instability of these fractures, severe damage may occur to the cartilage and subchondral bone of the articular surfaces of the lateral proximal sesamoid bone and proximal lateral proximal phalanx, which greatly reduces the prognosis for return to an athletic career (Figure 10). Therefore, displaced condylar fractures should ideally be repaired as soon as the horse can safely undergo a general anaesthetic. Additionally, arthroscopic examination of the entire joint at the time of surgery allows the surgeon to give a more accurate prognosis. Once the fracture is reduced, cortical screws are routinely placed in lag fashion. In severely comminuted or displaced fractures, consideration should be given to the use of 5.5mm cortical bone screws. Horses should be recovered from general anaesthesia in a half-limb cast that can subsequently be removed if the post-operative radiographs show accurate fracture reduction and stabilisation.

MEDIAL CONDYLAR FRACTURES

Medial condylar fractures may be treated conservatively in a full-limb cast in combination with strict box rest. As a cast does not completely stabilise the fracture, horses continue to experience significant pain and discomfort for several days to weeks. Consequently many will try to lie down after the first few days when they become tired. This should be avoided at all costs by tying the horse to an overhead line, as any attempt to stand could result in catastrophic fracture within the cast. Keeping horses tied

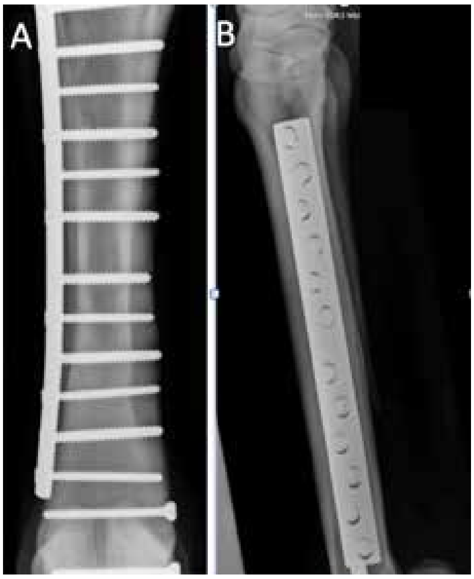

Figure 11: A. Dorsopalmar radiographic projection of a spiralling medial condylar fracture of the left MCIII repaired using two 4.5mm cortical bone screws placed in lag fashion and a laterally positioned dynamic compression plate. Lateral is to the left of the image. B. Lateromedial radiographic projection of the same horse.

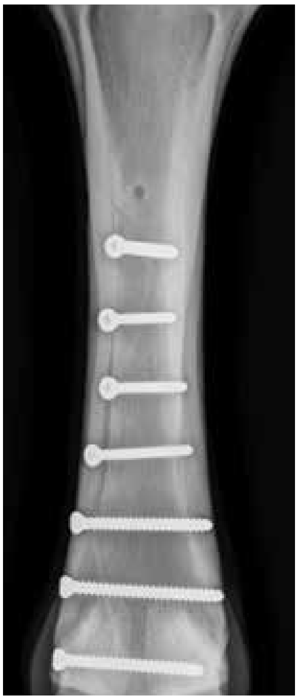

Figure 12: Spiralling medial condylar fracture of the left MCIII repaired with 4.5mm cortical bone screws placed in lag fashion with the horse standing. The distal most screws are placed in a lateral to medial plane with an attempt to place the more proximal screws perpendicular to the fracture line. This radiograph was obtained two days after surgery, note propagation of the fracture line beyond the most proximal screw. This horse developed mild contralateral limb laminitis. Lateral is to the left of the image.

up brings with it its own problems, primarily respiratory infections as the horse is unable to lower its head to drain the normal respiratory secretions. It is also worth noting that catastrophic fracture can still occur without warning up to six weeks after the initial fracture episode if conservative treatment is chosen.

Surgical stabilisation using internal fixation is therefore the treatment of choice for medial condylar fractures as it offers the greatest chance of the horse returning to an athletic career and greatly reduces the risk of catastrophic bone failure and other complications associated with conservative management. Both standing and recumbent techniques have been described.[20-24] Currently the gold standard is internal fixation of medial condylar fractures using cortical bone screws and a bone plate applied in neutral fashion (Figure 11). Under general anaesthesia, two cortical screws are placed in lag fashion in a similar manner as for a lateral condylar fracture but from medial to lateral. A 4.5mm broad dynamic compression plate (DCP), LC (limited-contact)-DCP or LCP (locking compression plate) is then applied laterally in neutral fashion beginning distally at the level of the second condylar screw, and extending to the proximal end of MC/MTIII. A 2-3cm long incision is created at the proximal end of MC/MTIII and a subcutaneous tunnel is formed using a plate passing device. In this way the plate is applied to the bone in a minimally invasive manner and the screws are placed via small percutaneous stab incisions.[2] I generally alternate between 4.5mm and 5.5mm cortical screws through the plate, with the distal one to three plate screws placed in lag fashion across the fracture. There are two reasons to apply the plate laterally; the mid-section of the fracture is typically relatively axial and therefore, a plate applied to the lateral aspect of the bone is biomechanically equivalent to a medially applied plate, and subsequently the plate can be more easily removed from the lateral aspect in a standing horse particularly for MTIII fractures after 60 days.

Other techniques previously described include: placement of screws in lag fashion, following the direction that the fracture spirals[22] (Figure 12) and placement of screws in lag fashion from lateral-to-medial in the standing horse.[24] There have been successful outcomes reported with these techniques, however, this is the risk of a catastrophic outcome with further propagation of the fracture line post-operatively, as well as life-threatening contralateral limb laminitis. In contrast, when a bone plate is applied horses are usually sound at a walk within 24-hours. Like lateral condylar fractures, medial condylar fractures treated with internal fixation heal faster and return to training sooner.

More recently horses identified as having prodromal signs of condylar fracture either via scintigraphy or MRI, or that have a nerve blocking pattern consistent with condylar inflammation and pain, have been treated by drilling one or more 3.2mm holes in a lateral to medial plane across the palmar and distal aspect of MC/MTIII. To date, there have been no published reports of the outcome of this technique, however, subjectively it appears to be reasonably successful, particularly in horses that experience recurrent lameness in the face of adequate rest periods.

PROGNOSIS

Advances in diagnostic capabilities, surgical skill sets and implant development have greatly improved the prognosis for equine long bone fractures. Multiple factors such as pre-existing joint pathology, side and size of fracture, displacement, comminution, treatment modality, and complications such as implant infection and failure are all important factors in determining outcome. Such complicating factors may not be of significance if the horse is intended for one of the less demanding equine disciplines, however, racehorses are typically less forgiving and these factors may preclude them from returning to their intended level of performance.

Overall, lateral MTIII factures warrant a better prognosis than MCIII fractures.[2] In general, the narrower the fracture fragment (as viewed in a lateral to medial plane on a dorsopalmar/plantar radiograph), and the longer the fracture from distal to proximal, the poorer the prognosis.[25] The presence of palmar/plantar comminution will also result in a diminished prognosis. Concurrent axial fracture of the proximal sesamoid bone generally precludes the horse from returning to any type of athletic career, however, a few horses may be salvaged for light pleasure riding or breeding.[26] Non-displaced lateral condylar fractures carry the best prognosis with over 80% of TB horses returning to racing. Displaced lateral condylar fractures on the other hand have a less favourable prognosis, with approximately 50% being able to return to racing.

Medial condylar fractures, despite the extent and severity of the fracture, typically offer a favourable outcome. The published prognosis for a return to racing ranges from 27-26%[24,27], with an even greater number being functional for another less demanding career. The majority of complications occur in the pre-operative or early post-operative periods, and generally consist of catastrophic bone or bone-implant failure. As with lateral condylar fractures, medial condylar fractures treated surgically have a superior outcome compared with those treated by conservative means.

In summary, condylar fractures are relatively common injuries in horses. Surgical intervention allows the majority of horses to return to their intended function. In the future, advances in diagnostic capabilities may allow us to more accurately predict and identify prodromal signs of impending condylar fractures and institute corrective measures before macroscopic fracture occurs.

It is hoped that further investigation to identify and analyse risk factors associated with the development and propagation of condylar fractures will allow us to institute recommendations to reduce the incidence of precipitating factors.

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