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A Lateral Approach to the Repair of Propagating Fractures of the Medial Condyle of the Third Metacarpal and Metatarsal Bone in 18 Racehorses

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Objectives—To report the technique, observations on fracture configurations and results of treatment by fixation lag screw following the fracture plane determined by an approach to the third metacarpal/metatarsal bone (MC3/MT3) that begins laterally over the metacarpo(metatarso)phalangeal joint and extends dorsally over the diaphysis of the bone.
Study Design—Case series.
Animals—Thoroughbred horses ($n = 18$) with propagating fractures of the medial condyle of MC3/MT3.
Methods—Retrospective analysis of case records of horses with fractures of the medial condyle of MC3/MT3 that propagated sagittaly or in a spiral configuration into the diaphysis, repaired surgically under general anesthesia by screw fixation in lag fashion through a lateral approach with periosteal reflection.
Results—Fractures were readily identified at surgery, enabling screw fixation in lag fashion following the fracture plane. Fracture configurations varied and could be classified as sagittal and spiral fractures with fractures within each group generally following a similar course. All horses recovered relatively uneventfully from general anesthesia and surgery, and all fractures healed well. Thirteen horses returned to training; 5 subsequently raced.
Conclusions—Repair of propagating sagittal and spiral fractures of the medial condyle of MC3/MT3 with diaphyseal involvement, through a lateral approach with periosteal reflection permits stable fixation with minimal complications. In this series there were no catastrophic failures.
Clinical relevance—Fractures of the medial condyle of MC3/MT3 that propagate either sagittaly or in a spiral configuration into the diaphysis can be successfully repaired with screw fixation in lag fashion using a lateral approach with periosteal reflection.
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INTRODUCTION

FRACTURES OF the condyles of the third metacarpal (MC3) or metatarsal (MT3) bone are relatively common injuries in Thoroughbred racehorses[1] and are the commonest long bone fracture of horses in training.[2] Fractures of the medial condyle are less common than fractures of the lateral condyle, accounting for between 5% and 35% of fractures[1,3–5] but are more likely to propagate into the diaphysis.[1,5–7] This may occur as part of the initial osseous failure or may follow (or at least be recognized) subsequently. This propensity, together with a lack of accurate radiological predictability of fracture configurations has resulted in a spectrum of opinions with respect to case management. Repair by screw fixation in lag fashion under general anesthesia through short (stab) incisions at points determined by the radiographically predicted fracture configuration has resulted in further propagation and/or inadequate repair.[1,8] In an attempt to reduce mortality, others have advocated plate

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fixation[9–11]; however, a second surgical procedure is required to remove the plate if the horse is intended to race. Recently, others have attempted to reduce the incidence of postoperative catastrophic failure by standing repair techniques that may involve only repair of the metaphyseal and epiphyseal portions of the fracture[12] or include the diaphysis.[7] Others have suggested conservative management in an attempt to minimize risks[3,13]; however, complications are common. Some horses succumb to catastrophic failure[1,3,8] and contralateral overload laminitis or degenerative joint disease are other potential sequelae (I. M. Wright, 2009, unpublished data).

It has been suggested that fractures of the medial condyles of the MC3/MT3 propagate either by extension of the fracture in the palmar/plantar cortex proximolaterally, with the fracture in the dorsal cortex extending proximomedially, or that the fractures in both cortices remain sagittal as they progress proximally in the diaphysis.[1,6,14] Other configurations occur,[8] but on the premise that fractures most commonly follow this course, we hypothesized that the fracture configuration as it propagates in both the dorsal and palmar/plantar cortices could most accurately be determined by an approach to MC3/MT3 that begins laterally over the metacarpo/metatarsophalangeal (MCP/MTP) joint and extends dorsally over the diaphysis of the bone. Our objectives were to describe this technique, and report observations on fracture configurations in 18 horses, and outcome after treatment by screw fixation in lag fashion following the fracture plane determined by this approach.

MATERIALS AND METHODS

Inclusion Criteria

Medical records (January 2003–2008) of horses admitted with sagittal or spiral (1 or both fracture lines changing orientation from parasagittal) fractures of the medial condyle of MC3/MT3 that propagated into the diaphysis were reviewed. Horses were included if the fracture was repaired under general anesthesia with screw fixation in lag fashion using a lateral approach with periosteal reflection. Horses were excluded from further study if a lateral approach was not used for repair. Retrieved data were horse age, breed, gender, duration of clinical signs before admission, screw position, complications, and outcome.

Diagnostic Procedures

All horses had radiographic examination of the affected MC3/MT3 including dorsopalmar/plantar, lateromedial, dorsal 45° lateral–palmar/plantaromedial and dorsal 45° medial–palmar/plantarolateral projections. Additional oblique radiographs were obtained to define fracture configuration. The contralateral MC3/MT3 was evaluated also radiographically in each horse.

Preoperative Planning

The thickness of MC3/MT3 bone at the expected sites of screw insertion was measured and marked on the radiographs. At each site, the distance from the cis-cortex to the radiologically determined fracture line was also measured.

Shoes were removed from all hooves except the contralateral limb in preparation for cast application.

Surgical Technique

Under general anesthesia, horses were positioned in lateral recumbency, with the affected limb horizontal, extended, and uppermost. The vascular supply to the distal aspect of the limb was minimized by distal to proximal application of an Esmarch bandage, and then a tourniquet applied to the distal antebrachium or crus. MC3/MT3 was approached through a curvilinear skin incision (distolateral to proximodorsal), from the level of the MCP/MTP joint to a point on the diaphysis proximal to the radiologically determined termination of the fracture. The incision was continued through the subcutaneous tissues and periosteum, which was reflected to permit close inspection of the MC3/MT3 cortex for fracture lines. This required periosteal reflection up to the lateral interosseous space and beneath the lateral and common or long digital extensor tendons; separation of the former and retraction with hand-held retractors also were necessary. Dissection extended proximally until normal dorsal and lateral cortices were identified.

Once the fracture configuration had been determined as accurately as possible, a needle was placed in the proximal one-third of the epicondylar fossa of MC3/MT3 with further needles at proposed proximal screw sites. A dorsopalmar/plantar radiograph was then taken. Using standard AO/ASIF technique, 4.5 mm cortical screws were inserted in lag fashion perpendicular to the fracture at 25–35 mm intervals from the epicondylar fossa to the proximal limit of the identifiable fracture. Where the fracture could be observed in both cortices, screws were placed half way between the fracture lines and angled perpendicular to the anticipated fracture plane. When the fracture was visible in only the dorsal cortex, screws were positioned dorsolaterally and angled palmar/plantaromedially to follow the spiral configuration of the fracture. All screws were placed bi-cortically. On completion of the repair a further dorsopalmar/plantar radiograph was taken. The metacarpal/metatarsal fascia and periosteum and subcutis were closed with simple continuous sutures of 0 or 2–0 polyglactin 910, and the skin with stainless-steel staples.

Postoperative Care

After surgery, the distal aspect of the limbs were protected and immobilized with a combination cast (inner layer of plaster of Paris and outer layer of fiberglass) in an extended position to the level of the third carpal/tarsal bones. Horses were allowed to recover from general anesthesia either unaided, or assisted to stand with head and tail ropes.

RESULTS

Twenty horses with propagating fractures of the medial condyle of the MC3/MT3 were identified; 18 had fracture repair through a lateral approach with periosteal reflection (Table 1). Two horses were excluded because the fracture was repaired using a medial approach.

Fractures (Figs 1 and 2) were readily identified during surgery with subperiosteal and intracortical hemorrhage common distally but less common proximally where fracture lines frequently were identified only as fine linear defects in the cortex. Six propagating fractures remained parasagittal and 12 had a spiral configuration beginning sagittaly and turning into an oblique frontal plane in the middle third of the diaphysis. Fractures that remained parasagittal terminated at variable points but consistently within the middle one-third of the diaphysis.

Spiral fractures that extended into the proximal one-third of MC3 or MT3 had a less predictable course; 7 remained in a frontal plane whereas 4 appeared to turn back into an oblique configuration. In 9 spiral fractures, the fracture line that began in the palmar/plantar subchondral bone of MC3/MT3 turned laterally in the distal diaphysis to emerge dorsally in the distal one-third of the lateral interosseous space. One palmar fracture line emerged distal to the 4th metacarpal bone and then disappeared into the distal quadrant of the interosseous space (Fig 1—orange dotted line) and in the other 2 horses, the palmar fracture line did not emerge laterally.

The fracture line that began in the dorsal subchondral bone of the medial condyle of the MC3/MT3 in those fractures that adopted a spiral configuration, remained consistently parasagittal into the middle one-third of the diaphysis (Figs 1A and 2A). One extended no further proximal, but the palmar fracture line extended further and spiraled (Fig 1A—red dashed line). Two then coursed laterally and 9 medially, with 7 of these entering the medial interosseous space; 2 in the middle, and 5 in the proximal one-thirds of the diaphysis (Figs 1A and 2A).

The fracture configuration as determined at surgery was accurately predicted radiographically in only 6 horses (5 longitudinal fractures, 1 spiral fracture). The surgically identified proximal extent of the fracture was predicted accurately radiographically in only 9 horses.

The only surgical complications to occur were engagement of the 2nd metacarpal bone with an obliquely positioned screw in the mid-diaphysis in 2 horses and stripping of 4 screws (3 horses) necessitating replacement with 5.5 mm cortical screws.

All horses recovered uneventfully from surgery. Twelve horses were recovered from anesthesia without assistance and 6 horses were assisted to stand with head and tail ropes. All horses were administered perioperative sodium benzyl penicillin (30,000 U/kg intravenously [IV]) and gentamicin sulfate (2.2 mg/kg IV), which were continued every 8 hours for 3–11 (mean, 5.7) days after surgery. Horses were administered phenylbutazone (4 mg/kg IV) immediately before surgery and in 6 horses, administration was continued for 2–41 (mean, 14.8) days postoperatively. Limb casts were maintained for 4–28 (mean, 16.2) days after surgery. In 13 horses, casts were removed electively after a desired period of external support.

Table 1. Clinical Summary of 18 Thoroughbred Racehorses with Propagating Fractures of MC3 and MT3

Horse	Age	Gender	Limb	Fracture Configuration	Number of Screws	Timing of Screw Removal (Days)	Outcome
1	2	Filly	RH	Spiral	7	282	Screws removed because of lameness, subsequently trained, unraced
2	2	Filly	LH	Spiral	5	NA	Retired because of lameness related to fracture
3	2	Filly	LF	Spiral	6	NA	Trained, unraced
4	3	Colt	LH	Sagittal	4	NA	Trained but went lame because of degenerative joint disease of the metatarsophalangeal joint of the operated limb
5	2	Gelding	LH	Spiral	6	NA	Raced 17 times, placed twice
6	3	Colt	RF	Spiral	7	111*	Raced 23 times, won 3, placed twice
7	2	Filly	RF	Sagittal	4	NA	Trained, unraced
8	3	Colt	RF	Spiral	8	NA	Retired to stud with no attempt to resume training
9	2	Filly	RH	Spiral	6	NA	Trained, unraced
10	2	Colt	RH	Spiral	6	NA	Trained, unraced
11	4	Gelding	LF	Spiral	8	116*	Trained, unraced
12	3	Filly	RF	Sagittal	4	NA	Retired to stud with no attempt to resume training
13	2	Colt	RH	Sagittal	4	NA	Raced 5 times, won once and placed once
14	2	Filly	RH	Spiral	9	NA	Euthanatized—pelvic fracture during convalescence
15	2	Colt	LF	Sagittal	4	NA	Raced 8 times, won twice and placed 3 times
16	2	Colt	RF	Spiral	5	103*	Raced 3 times, won twice
17	3	Colt	RF	Spiral	8	105*	In training
18	3	Colt	RH	Sagittal	4	NA	In training

*Elective screw removal.

RF, right fore; RH, right hind; LH, left hind; LF, left fore; MC3, third metacarpal; MT3, third metatarsal.

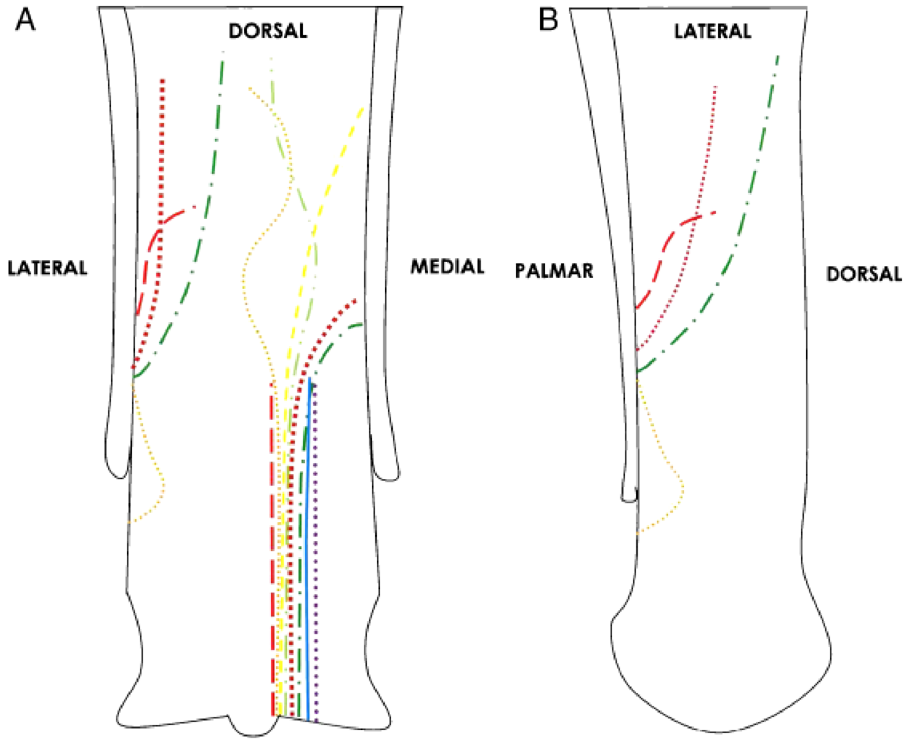

Fig 1. Schematic illustrations of the third metacarpal bone (MC3) depicting the fracture configurations identified at surgery. (A) Dorsal aspect and (B) lateral aspect.

In 5 horses, casts were removed early because of development of cast sores. Only 1 horse required placement of a 2nd cast, which was performed standing. One horse developed incisional drainage and was administered enrofloxacin (5 mg/kg IV once daily); drainage subsequently resolved uneventfully.

Implants were removed from 5 horses, 103–282 (mean, 144.2) days after fracture repair (including the horses where a screw had engaged the 2nd metacarpal bone). Implants were removed under general anesthesia through an open approach and horses recovered unassisted in half limb casts. In all 5 horses, the fracture had a spiral configuration and more proximal screws were positioned in, or close to, dorsopalmar/plantar positions. In 4 of these horses, all screws were removed electively whereas in 1 horse, only the 4 proximal of 7 screws were removed because of lameness upon resumption of training.

Outcome (Table 1)

Fourteen horses returned to training. Three of these have not yet had sufficient time since surgery to reach race fitness. Of those returned to training, 2 developed lameness related to the fracture, including the horse that had the screws removed (allowing an uneventful return to training). Five horses have raced. Of the 4 remaining horses, 3 were retired to stud (1 because of lameness and 2 for economic reasons) without attempting resumption of training, and 1 horse was euthanatized after an unrelated catastrophic pelvic fracture while convalescing. Too few horses raced before or after injury to make any meaningful comparison of pre- and postinjury performance.

DISCUSSION

Propagating medial condylar fractures followed either a longitudinal or spiral configuration. For spiral fractures, most has a similar configuration with the fracture propagating in the palmar/plantar cortex proximally and laterally, and in the dorsal cortex proximally and medially. A lateral surgical approach facilitates, in the most cases, the surgeon to see the fracture as it propagates in the dorsal cortex and from the palmar/plantar cortices into the lateral cortex. The advantage of direct fracture observation is the ability to insert screws perpendicularly, in a biomechanically optimal position, along the entire length of the fracture.

Although minimally invasive, screw fixation in lag fashion through stab incisions, from the medial aspect of MC3/MT3[8] under general anesthesia has the disadvantage of not allowing the surgeon to see the fracture. Implants are placed under radiographic control, but the ability to place all implants perpendicular to the fracture is severely compromised. As our results illustrate, radio-

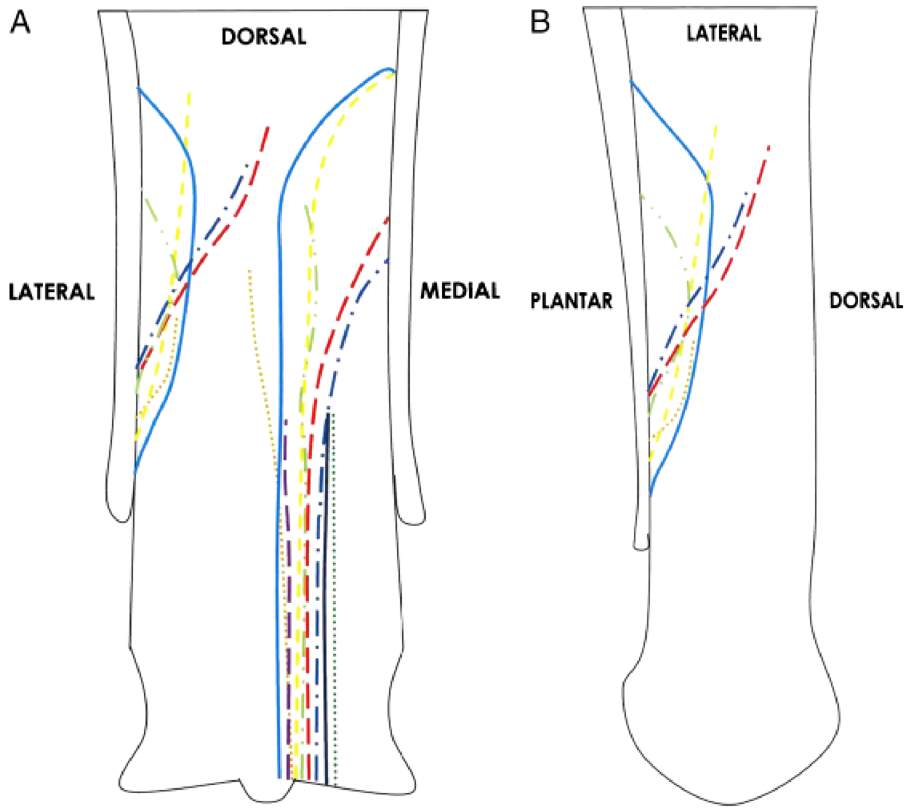

Fig 2. Schematic illustrations of the third metatarsal bone (MT3) depicting the fracture configurations identified at surgery. (A) Dorsal aspect and (B) lateral aspect.

graphic prediction of fracture configurations is unreliable. There is thus a risk of inadvertently entering an occult fissure fracture while drilling, with potential catastrophic consequences. In addition, as we observed and as reported by Richardson,[8] fractures may extend further proximal than is radiographically discernable. A lack of compression applied to the proximal portion of the fracture will result in a biomechanically compromised fixation, and the risk of propagation in the postoperative period is increased. These limitations are demonstrated by the high rate of catastrophic fracture propagation during recovery from general anesthesia or in the immediate postoperative period.[8]

The highest risk period for catastrophic fracture propagation is during anesthetic recovery. Recent reports have described screw repair in lag fashion through stab incisions in the standing, sedated horse,[7,12] eliminating the need for general anesthesia. Screws were placed no further proximal than the radiographically discernable limit of the fracture. The technique retains a minimally invasive approach, and a minority of horses require a second surgical procedure for implant removal. The limitations described above for closed screw repair in lag fashion still apply, although the incidence of catastrophic propagation appears to be reduced.

Plate fixation of propagating fractures has been described; Zekas et al[15] performed screw fixation in lag fashion with additional support provided by a dorsal cortical, dynamic compression plate (DCP). Goodrich[10] described application of a broad DCP that begins on the medial surface of the MC3/MT3 distally and spirals dorsoproximally. An additional distal screw in lag fashion may or may not be inserted through the epicondylar fossa. James and Richardson[11] described fixation with distally positioned screws in lag fashion and a dorsolateral broad DCP spanning the diaphysis of the MC3/MT3, applied using a minimally invasive technique. The advantages of these techniques are increased stability of the repair, with a subsequent reduction in catastrophic postoperative fracture propagation. However, a second surgical procedure for plate removal is required if the horse is intended to race.

Compared with the minimally invasive approach, there are potential disadvantages with the technique we report because it is performed through an open incision with periosteal reflection. In other species, biological osteosynthesis achieved by indirect reduction of comminuted fractures has been shown to result in faster, more efficient bony bridging.[16,17] Minimally invasive percutaneous plate osteosynthesis in rabbits had a tendency for lower infection rates[18]; James and Richardson[11] reported incisional infection in 2 of 23 propagating condylar fractures repaired by minimally invasive plate application, but both of these occurred after plate removal. No incisional complications were described in the 17 horses repaired standing by screw fixation in lag fashion[7,12]; however, no demonstrable difference in the rate of incisional infection was seen in our horses compared with the reported minimally invasive techniques. The average duration to 1st race after surgery (11.6 months) was similar to the minimally invasive techniques (standing repair, 11.8 months[7]; minimally invasive plate fixation, 11.6 months[11]), suggesting a lack of significant effect on speed of fracture healing.

In our horses, all that had implants removed, had proximal screws positioned in or close to a dorsopalmar/plantar orientation. Four other horses with dorsopalmar/plantar positioned screws returned to training without screw removal, although only 1 raced. None of the horses with screws positioned only in a lateromedial plane had the screws removed. We hypothesize that dorsopalmar bending of MC3/MT3 at fast gaits, results in pain when bicortical dorsopalmar/plantar implants are left in situ and recommend that screws in this orientation be removed once satisfactory fracture healing has occurred.

Despite documented previously, concerns about propagation and catastrophic failure of medial condylar fractures of the MC3/MT3 during recovery from general anesthesia,[1,8] none of our horses had any problems. Other reports recommend full limb cast application after repair of medial MT3 condylar fractures,[8,10,19] and/or assisted pool or sling recovery systems.[11] In our series, head and tail rope assistance was provided during anesthetic recovery only to horses considered temperamentally suitable and with a long spiral component. All horses had half limb casts only applied to the level of the third carpal/tarsal bones. It is considered that the biomechanically favorable aspects of the reported repair technique facilitated this approach. However, it should be noted that regardless of the method of fracture repair chosen, the potential for catastrophic failure always remains.

It should be noted that not all propagating medial condylar fractures are suitable for repair using the technique we describe. In 2 horses admitted during the study period, a medial approach with periosteal reflection was used. This was chosen because of fracture configuration; in both horses, although the fracture in the dorsal cortex remained parasagittal, the fracture in the palmar/plantar cortex spiraled to the medial aspect of MC3/MT3, and in these instances a lateral approach would not have provided any further information about the fracture configuration. In both horses this was readily apparent radiologically, and instead, a medial approach was made allowing identification of the fracture propagating in/from both the dorsal and palmar/plantar cortices. Fractures may also have a more complex configuration with more than 2 major pieces (e.g. crossing fracture lines or a Y configuration in the mid-diaphysis[8]), or the configuration may not be clear, and in these instances additional methods of internal fixation are required (e.g. plate fixation).

We concluded that the configuration of fractures of the medial condyle of the MC3/MT3 bone can be accurately determined in most horses by a lateral approach with periosteal reflection, and this enables stable fixation with minimal complications. Using this technique none of our horses had catastrophic failure of the repair.

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