CT GUIDED FRACTURE FIXATION IN THE FOOT
Dean W. Richardson DVM, DACVS
New Bolton Center, University of Pennsylvania, Kennett Square PA

It has become a generally well-accepted tenet that displaced articular fractures are optimally treated with lag screw fixation. Proper use of lag screw fixation helps restore normal anatomy, optimize articular healing and minimize the development of osteoarthritis. Providing immediate stability can immediately improve comfort on the injured limb and minimize contralateral problems. Fractures of the distal phalanx and navicular bone have been difficult challenges because of the inability to expose these bones and because the hoof requires an incision that, technically speaking, does not “heal”. It is definitely feasible to repair fractures within the hoof using extensive intraoperative fluoroscopy or digital radiography but computed tomography affords an easier, more accurate solution.

For example, a displaced articular wing fracture of the distal phalanx is exceedingly difficult to “hit” accurately with a fluoroscopically guided screw. The surface geometry of the distal phalanx is complex, hidden by hoof wall and the fracture plane cannot be directly observed. Furthermore, the “target” of the wing of P3 is quite narrow. An even greater challenge for internal fixation is a navicular bone fracture. Even a 3.5 mm screw is a tight fit and must be perfectly positioned to avoid iatrogenic injury to a gliding surface.

CT assistance makes this surgery feasible and relatively easy. (Purchasing the CT is the most difficult part of the surgery…..) We use a small bore, portable CT unit within the operating suite. Ours is the Neurologica CereTom with an approximately 32 cm bore. This has enormous advantages for injuries from the mid-radius/mid-tibia distally but will not accommodate an adult horse head. A larger CT unit more distant from the OR could still be used but intraoperative use would usually be impractical. Another piece of equipment that is highly useful is an aiming device for drilling. We use the Synthes combined aiming device (Synthes catalog 130.30) but it is possible to make a homemade version of such a device.

Preparation and Lag Screw Fixation:

1- I do not recommend cleaning the hoof the night before surgery. After the horse is anesthetized, use a motorized grinder to remove the superficial layer of the wall and use a hoof knife to remove the superficial sole. Do a basic cleaning (not final prep) of the hoof.

2- Estimate where you think the drill would enter the hoof in order to optimally cross the fracture. Place a small (1-2 mm) bleb of barium paste there.

3- Estimate the location of the hoof where the drill bit would exit if you continued on the intended drill path. In wing fractures, this will be low on the heel, usually about 2 cm from the palmar/plantar margin but the position of the distal phalanx within the hoof is surprisingly variable. Place another bleb of barium paste at the site.

4- Perform the CT. Measure the estimated overall length of screw as well as the estimated depth of the glide hole.

5- Review the CT images and adjust the barium spots accordingly. REPEAT the CT to make absolutely certain that both the entrance location and “exit” sites are absolutely accurate. If they are perfect, the rest of the surgery is easy.
Uses a small (2-3 mm) drill bit to make shallow (~1mm) depressions at the marked sites.

The depressions need to be shallow enough to allow them to be scrubbed but deep enough that you can locate them under the adhesive drape.

The hoof can then be scrubbed as you would for routine surgical skin preparation. Duraprep® [3M] (iodine povacrylex) works particularly well because it adheres to the hoof and to an adhesive drape.

Place a pneumatic tourniquet proximally for later use. It is not necessary to inflate it until the conclusion of surgery.

Use a transparent adhesive drape (e.g. Ioban®).

Using the drilled spots for orientation, use a 5/16” machine or wood bit to make a hole through the hoof wall in the same direction of the intended drill path. This is just large enough to accommodate the screw head. Drill just through to the bone, not into the bone.

Use the aiming device by placing the drill guide into the hoof wall hole and the hook of the aiming device in the “exit” hoof wall depression.

Use routine lag screw technique. It is often possible to feel that you have entered the fracture plane with the glide hole bit but intraoperative fluoroscopy or digital radiography should always be done to confirm correct positioning. Do NOT overdress the glide hole. The thread hole needs every available millimeter.

If it is a very small target fragment, repeat the CT after drilling the glide hole to confirm that it is properly aimed. If it is not, correct the angle.

Complete the lag screw sequence. The co

In large enough fractures, strongly consider inserting a second screw to provide rotational stability and some additional compression.

Ideally, check the position of implants with CT. If impractical, check very carefully with appropriate fluoroscopic or radiographic images.

Start a regional limb perfusion with appropriate antimicrobial while the shoe is being applied.

Sealing the Hoof Wall Defect:

1- Inflate the pneumatic tourniquet to help dry the surgical field.
2- Fill the hole in the hoof with dry collagen sponge up to the level of the inner hoof wall. Put some amikacin (or your choice of antimicrobial) on the sponge. Add a bit more and repeat until the defect is well filled with antibiotic soaked sponge. It is important to fill up to the hoof wall so that the PMMA is not pressed too deeply.
3- Fill the hoof wall defect with antibiotic impregnated PMMA when it is in the doughy phase of curing. Wipe away excess to make the plug level with the hoof wall surface.
4- Apply multiple coats of cyanoacrylate tissue adhesive to seal any gaps between the hoof and the PMMA plug.
5- Place a permanent fiber patch with hoof adhesive over the plug. We use a carbon fiber fabric.
6- Apply a cuffed glue-on shoe with a full metal sole plate and impression material packing for additional stability.

Navicular Fractures: The basics for repair a navicular fracture are identical to those described above EXCEPT the navicular bone must be held as stable as possible during the fixation steps. We glue a stretch-free material (such as Kevlar) to the toe of the hoof and forcefully extend the
foot by pulling on the material proximally. The tightened strap is secured to the forearm or
gaskin over a padded bandage with inelastic tape. When complete, the deep digital flexor tendon
should be palpably very taut. The other difference with the navicular fractures is that I would
always prefer to take CT images after drilling the glide hole and after placing the screw. It is a
very small target.

Aftercare: An antibiotic regional limb perfusion is also performed on the day following surgery. I
prefer to maintain cuffed glue-on shoes for several months. It is essential that the attending farrier
understand that the deep patch over the plug should not be disturbed. It can be cut off in
sections as it reaches the bottom of the hoof several months later.

Complications: As is the case for most internal fixations, infection is the most common and most
serious complication. Strict adherence to technique and immediate meticulous sealing of
the hoof wall defect helps minimize the risk as will appropriate antimicrobial prophylaxis. Another potential
problem is contamination and seeding of the head of the screw if a hoof abscess travels up towards
the coronary band. This has been seen in one horse about 18 months following surgery, long after the
fracture was healed and the horse was back in work. The screw was removed and the infection fully
resolved.

Figure 1: An articular wing fracture of the distal phalanx transverse CT image taken a few mm
distal (below) the articular surface. Top right- small blebs of barium sulfate paste are placed in
depressions in the hoof to help aim the drill. Middle left-Approximate measurements can be
taken to help make the glide hole the correct length and to help estimate correct screw length.
Middle right- With CT assistance, the screw can be accurately placed in a small target. Bottom-
Lateral and DP postoperative views.
Figure 2: Dorsopalmar (A) and palmar tangential (B) views of an acute navicular bone fracture in an 11 year old Thoroughbred gelding. In (C)- a 2.0 mm hole is made to check drill placement. (D)- A 3.5 mm glide hole is made to the fracture plane. (E)- The 2.5 mm thread hole is continued through the larger fragment of the navicular bone. (F)- The final placement of the 3.5 mm screw. Orthogonal dorsopalmar (G) and lateromedial (H) projections confirm central placement of the screw.