# BOWED TENDONS NO HURDLE FOR VICTORIAN THOROUGHBRED TRAINER.

When Mazzacano and Sir Pentire went sailing past the post in first position in recent feature steeplechase races in Victoria, racehorse trainer Robbie Laing was surely responsible for two of the greatest training performances of all time. And in so doing, there are salient lessons to be learnt for anyone interested in the conditioning of sports horses. Especially those with tendon injuries.

Both horses were having their first race start for two years when they won their respective races carrying big weights over marathon distances and negotiating a number of large obstacles en route. Some feat for the fragile thoroughbred. The training effort was all the more remarkable given that both horses have a history of recurrent, chronic “bowed tendons”.

Laing was able to get both horses fit using an unconventional training regime. Take Mazzacano for example. Leading up to his historic win, Laing sent the horse to an unprecedented eight barrier trials, unofficial races where there is no imperative to push the horse to the line. The horse was allowed to regain peak fitness gradually without placing undue pressure on his vulnerable tendons. Five days before his comeback race Mazzacano galloped strongly over 1200m at Cranbourne before being floated to Pakenham where he contested a 2400m hurdle trial and a 2800m steeplechase trial. All before you and I are normally out of bed!

Figure 1: The mighty Mazzacano leaps high as he clears one of the big fences on his way to victory in the Australian Steeple on 13 June. Photo: *Getty Images.* Published SMH 14 June 2009.

Laing recognised the two evils that predispose all types of horses to tendon injuries: speed and fatigue. He was able to get his two steeds ready for first up wins by avoiding the high pressure speed of competitive racing and by gradually increasing their workload, ensuring that their cardiovascular and muscle fitness levels always exceeded their required workload and thus avoiding fatigue.

“Bowed tendons” or more precisely, superficial digital flexor tendinitis, remains one of the most common and devastating injuries affecting all forms of sport horses. The classic presentation of a “bowed tendon” is shown in Figure 2. There is obvious heat, swelling and pain of the superficial flexor tendon at the back of the cannon.

Overt lameness is not usually associated with bowed tendons. However horses with bowed tendons are reluctant to stretch out and fully load their damaged tendon under pressure. Thus they perform submaximally. Exceptions to the non lameness presentation for bowed tendons are horses with severe damage to the tendon such that the palmar support to the fetlock joint is compromised (and the fetlock drops when weight bearing) and “high” or “low” bows where the swelling occurs within the confined space of the carpal and digital annular ligaments respectively (Figure 2B).

In general, bowed tendons carry a poor prognosis for future sustained competitive athletic performance. Depending on the required workload, over two-thirds of tendon injuries will recur before the horse has regained full competitive capacity.

FIGURE 2A: Typical appearance of a "bowed tendon". There is obvious thickening and swelling of the mid third of the near fore superficial digital flexor tendon. The borders of the tendon are rounded and have lost their sharp definition.


FIGURE 2B: A "low" bow showing an obvious constriction caused by the palmar annular ligament of the fetlock. The damaged tendon is prohibited from swelling by the ligament that extends around the back of the fetlock. This creates increased pressure and usually an associated lameness. A similar process occurs with "high bows", just below the knee. Overt lameness is not usually a sign of mid body bows. High and low bows carry a poorer prognosis than mid body bows as the increased external pressure applies a further impediment to healing.

## FUNCTIONAL ANATOMY

The flexor tendons are the sinewy structures that allow more proximally located muscles to exert their forces on the pendulous levers of the equine limb and in so doing provide a system of energy efficient locomotion.

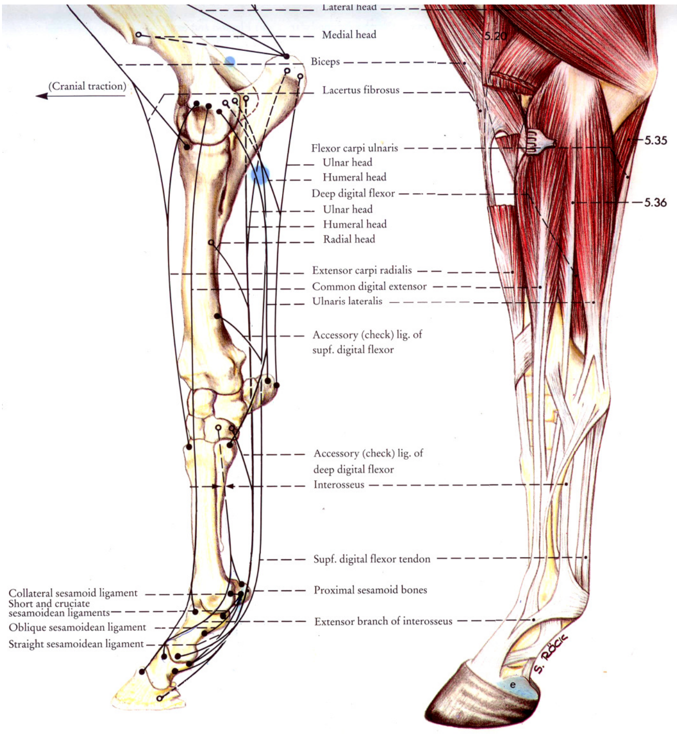


Figure 3A: The functional anatomy of the distal limb of the horse. The diagram on the left allows an appreciation of the fulcrum/lever model of equine locomotion. All the muscles of the limb are located proximal to the knee, a long distance from their eventual tendinous attachments. The tendons are responsible for transmitting the muscular force (contraction) to the bony levers. This design saves substantial quantities of muscular energy during locomotion but the long distances over which the tendons are required to exert their force predispose the tendon to problems. Reproduced from Anatomy of the Horse by Budras, Sack and Rock.

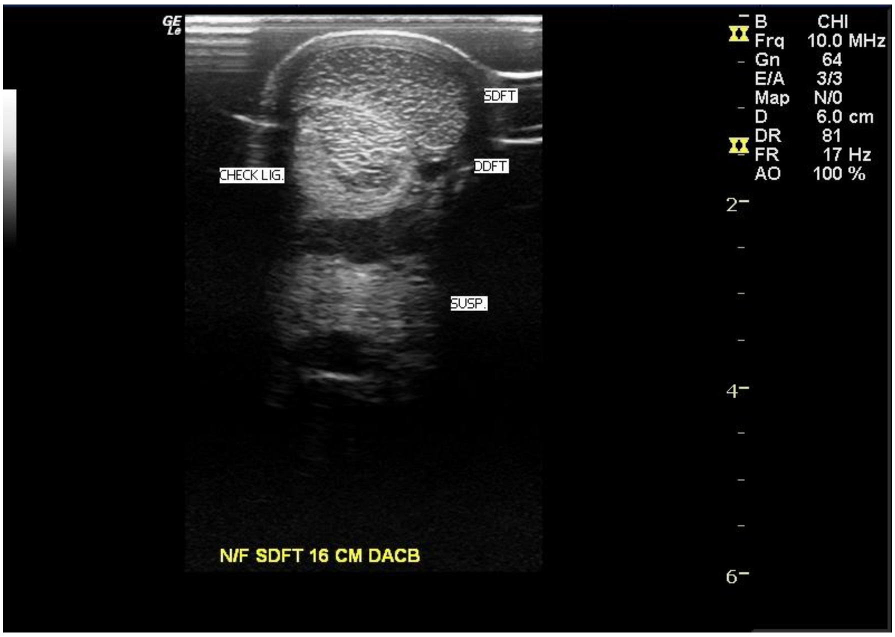


FIGURE 3B: The normal ultrastructural anatomy of the tendons can be visualised using ultrasound. The figure above shows the cross sectional anatomy. The superficial digital flexor tendon (SDFT) is the crescent shaped structure located at the top of the diagram. The cross sectional area of the tendon at this level is only about 1.2cm$^2$. During the weight bearing phase of the gallop, the entire horse's weight transfers over the tendons resulting in hyperextension of the fetlock joint (see Figure 3).

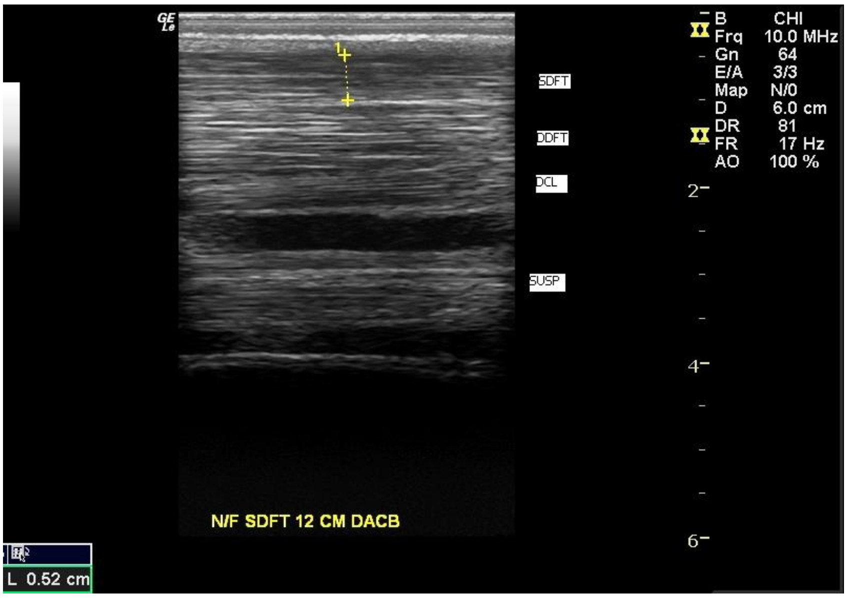


FIGURE 3C: Normal ultrasound anatomy of the tendons at the back of the cannon. The tendon fibres are aligned along the direction of force from proximal (LHS of screen) to distal (RHS of screen). SDFT = superficial digital flexor, DDFT = deep digital flexor tendon, DCL =distal check ligament, SUSP = suspensory ligament.

But the flexor tendons provide more than just structural support by acting as springs to store (potential) energy during the weight bearing phase of the stride. This energy is later released as both kinetic (energy of motion) and heat energy as the limb is unloaded and the “spring” recoils. The efficiency of this process has been measured to be an extraordinarily high 93%. Thus the horse is biomechanically propelled on a series of springs through a cycle of loading and unloading, similar to a four-legged pogo stick.

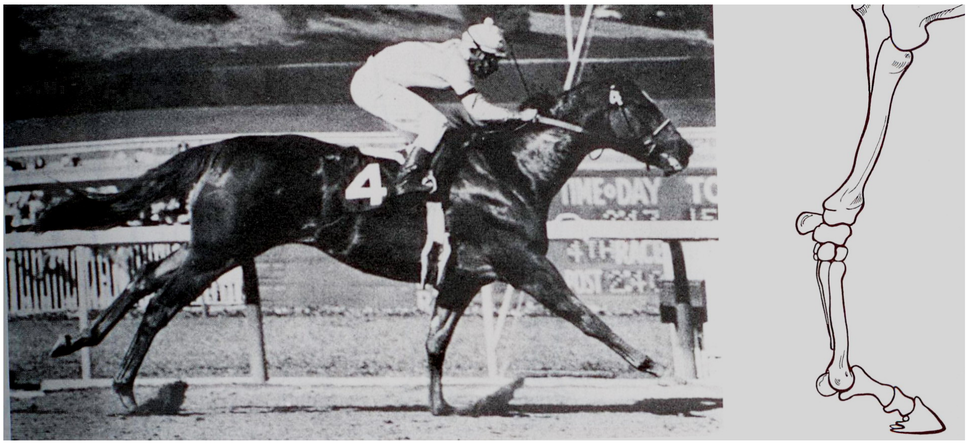

FIGURE 4: Horse in full gallop. Note the extreme hyperextension of the near fore fetlock during the weight bearing phase of the stride. The deformation of the tendon provides an energy store, which recoils and propels the horse as the tendon is unloaded. From Adam’s Lameness in Horses (5$^{th}$ Edition).

## BIOMECHANICS OF TENDON INJURIES

Injuries to the flexor tendons have traditionally been thought of as “strain” injuries caused by a sudden overloading of the tendon as its parent muscle begins to fatigue. This results in a transient hesitation in the recovery of the limb from the hyperextension of the full weight bearing phase of the stride.

The tendon is acutely and transiently overloaded, resulting in rupture of its constituent fibres.

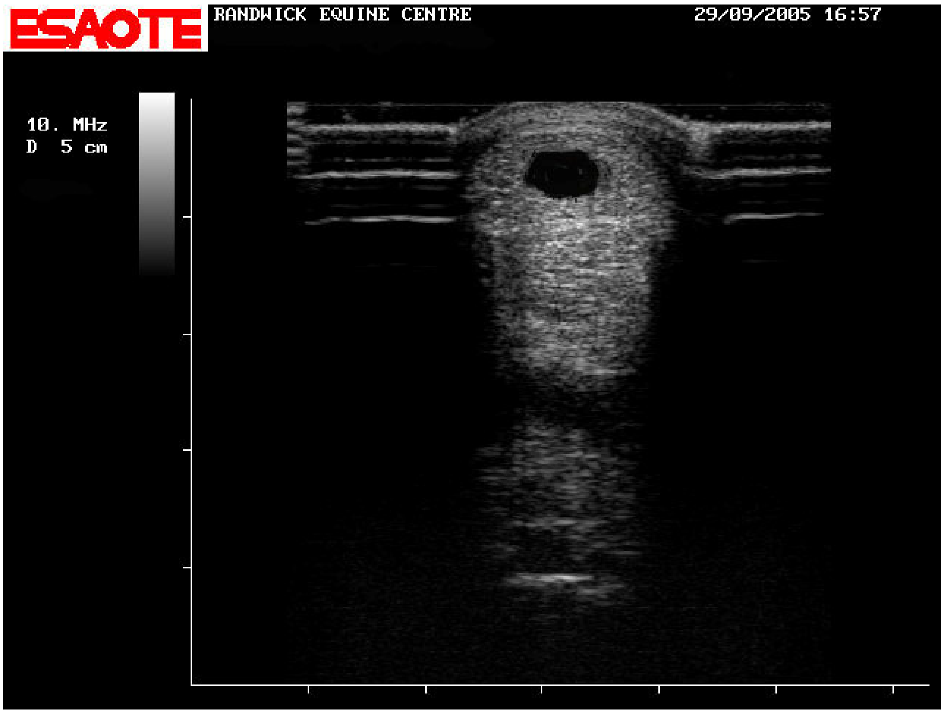


FIGURE 5: Ultrasound image of an acute “bowed tendon” (superficial digital flexor tendonitis). Note the large black hole in the middle of the tendon where there has been complete rupture of tendon fibres. A haematoma then forms in the middle of the tendon. Note that this “core lesion” is surrounded by a healthy rim of tendon tissue. This relatively impervious rim of healthy tissue makes it difficult for the in growth of blood vessels and migration of cells necessary to clean up the haematoma and initiate the healing process. These core lesions are ideal candidates for stem cell therapy as the rim tissue also provides an envelope to stop the leaking of the stem cells into the surrounding tissues.

Fatigue resulting in mistiming of the stride, remains a common cause of tendon injuries. Tendon injuries are more likely to occur towards the end of a race, cross-country, endurance ride or show jumping round. The longer and the more intense the exercise, the more likely it is to occur. They are more likely to occur on heavy ground (such as sand or rain affected going) and generally if the horse is not cardiovascularly and musculosketally fit for the required level of exercise.

Confirmation also plays a role in tendon injuries. The longer the lever (limb), the more strain is likely to be placed on the tendon during weight bearing. A typical confirmation that predisposes to tendon injuries is shown in Figure 6. Note the long, upright cannon bones and the “tucked in” appearance of the tendon behind the knee.

FIGURE 6: Typical conformation predisposing to tendon problems. Note the relative long length of the cannon bones and the upright conformation. The tendons are also “tucked in “ behind the knee. At the time this photo was taken, she was an unraced two year old. I am tipping her racing career will be over by three.

There is no doubt that inattentive trimming and/or shoeing plays a role in the propagation of tendon injuries. The long toe is the enemy of the tendon by changing the hoof-pastern-fetlock axis and placing additional loads on the superficial flexor tendon. The affects of the long toe are often exacerbated by the low, underslung heel, flat-footed conformation typical of most thoroughbred horses (Figure 7).

FIGURE 7: Long-toe conformation that predisposes horses to tendon injuries (as well as quarter cracks!). This horse's feet demonstrate a multitude of sins, including long toe, low under slung heels, lateral to medial imbalance and different shape and sized feet. Note the different angles of the coronary band.

More recent research has shown that the majority of tendon injuries are more likely a degenerative injury resulting from the accumulation of micro damage that progressively weakens the tendon. This micro damage largely remains undetected but alters the structural properties of the tendon. As tendons are already operating close to their biomechanical limits, it does not take much accumulated damage before the peak loading of the tendon during the weight-bearing phase of the stride exceeds its structural strength and results in disruption of the tendon fibres.

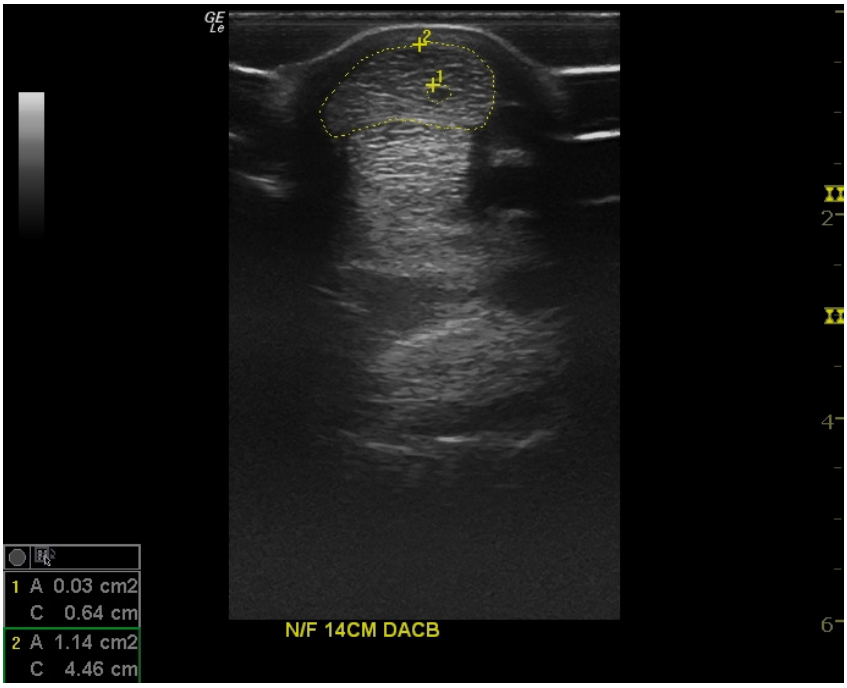


FIGURE 8: Ultrasound image showing microdamage (#1) in a superficial digital flexor tendon (#2). The small black hole was only apparent at one level of the tendon (14cm below the knee) and only represents 2% of the fibres within the tendon. The lesion was detected as an incidental finding on a routine scan.

Recent research has also shown that some tendon injuries may result from thermal injury. The potential energy stored by the deformation of the tendon during weight bearing is rapidly converted to kinetic (propulsion) and heat energy as the tendon in unloaded. Temperatures as high as 45$^{o}$C have been recorded in the core of the superficial flexor tendon during high speed exercise. If this heat is unable to be rapidly dissipated, it “cooks” the interior of the tendon. Low grade thermal injury may well be a significant part of the degenerative changes that occurs in the core of tendons prior to fibre rupture.

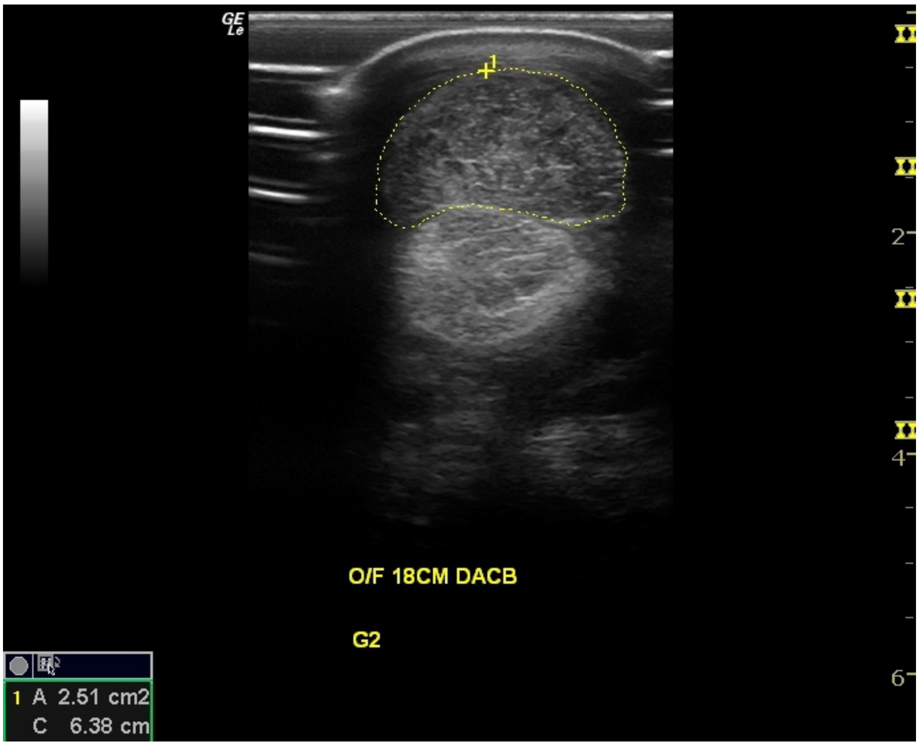


FIGURE 9: Ultrasound image of likely thermal injury to a tendon. This horse bolted on its rider and pulled up with “bowed tendons” in both forelegs. Note the severe generalised loss of tendon architecture and the marked increase in size of the tendon (twice normal). This tendon was likely “cooked” due to the generation of heat within the tendon after it galloped for three miles. This tendon will never regain strength and the prognosis for any future athletic activity is hopeless.

Horses that sustain a tendon injury are often bandaged in their subsequent work in an attempt to provide additional support to the damaged tendon and “unload” the tendon during hyperextension. It is dubious that bandages, boots or tape provide enough additional support to make a significant difference. However, they may decrease the dissipation of heat from the tendon and hence predispose them to ongoing thermal damage. Dalmar (http://205.252.250.27/dalmar/treatment.html) have a boot that offers sufficient support to be of value in unloading the tendon. However the boot is expensive ($1500) and its fitting is complicated.

FIGURE 10: The Dalmar Tendon Support boot provides realistic support to the fetlock joint during hyperextension thus unloading the superficial digital flexor tendon.

**TREATMENT OF TENDON INJURIES**

Healed tendon is “stiffer” than normal tendon and this compromises the tendon function and predisposes it to re-injury, usually at sites adjacent to the original injury and never within the healed scar (providing adequate healing has occurred).

There have been several new developments for the treatment of acute traumatic tendon tears. These generally involve the injection of biological growth/repair stimulation factors, such as Insulin-like Growth Factor-1 (Tendotrophin) or Platelet Rich Plasma (PRP) or the use of stem cells (from either bone marrow or fat tissue). Although the preliminary results appear promising, the long-term follow up on large numbers is currently not available and treatment is expensive (approximately $6500 for stem cell therapy). There is no evidence that the convalescent time is reduced with any of these treatments and it remains at 9-12 months. The best results appear to be when these treatments are used in conjunction with a regular rehabilitation program.

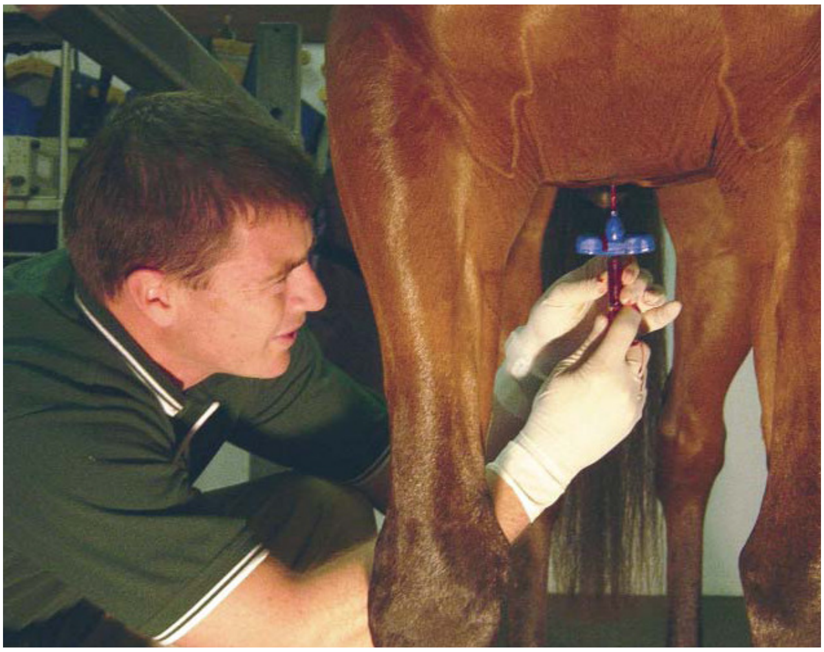

FIGURE 11: The harvesting of stem cells from the bone marrow of the horse's sternum. The bone marrow is incubated under special growth conditions for three weeks until a sufficient number of stem cells are available for re-injection into the damaged tendon. Preliminary results are encouraging, but not definitive.

The cornerstone of any successful tendon comeback remains the rehabilitation program. Early and progressive mobilisation incorporating a slow graduated exercise program where the horse is progressed through a series of regulated exercise levels starting with walking, then trotting, cantering, etc. The level of exercise is determined by regular clinical appraisals of the tendon (swelling, pain) in conjunction with regular ultrasound checks. It is a process of "advance and retreat"and "tear and repair" with some re-tearing likely and necessary for good tendon repair. There are many different ways of achieving a regulated exercise program including co-training with pacers, inclined treadmill, water walkers and unstructured ("turn the horse out in the hills"). One potential down side of a rehab program is that it dulls natural speed and promotes endurance. Thus horses that rely on their speed for competition (such as sprinters, quarter horses, barrel races, etc) are often sound but not as competitive as prior to their injury. Robbie Laing has again shown just how successful a well-orchestrated rehabilitation program can be.

A detailed account of treatment for tendon injuries remains the subject for a future article.

**SHOEING FOR TENDON INJURIES**

There is probably at least an element of truth in the adage that an "ounce on the foot is equivalent to a pound on the back". Given that at least some tendon lesions are due to premature fatigue it would seem logical that horses with tendon injuries should be shod in the lightest possible format (ie aluminium plates) at all times when working.

The mechanics of shoeing for tendon injuries was recently described by Denoix (Proceedings of the 28th Bain Fallon Lectures). Elevation of the heels results in flexion of the coffin (P2-P3) joint and a relaxation of the deep digital flexor tendon. Because of this relaxation, the fetlock joint overextends and this places additional strain on the superficial flexor tendon.

Conversely, elevation of the toe induces extension of the coffin joint and increases the stress on the deep flexor tendon and helps offload the superficial flexor tendon. Elevation of the toe is not a practical solution but its effects can be mimicked by shoeing with a wide toe and narrow heels. This shoe should be applied during the initial phase of tendon repair (0-3 months), and maintained for two shoeings.

From three to six months after the initial injury a shoe with a wide toe and narrow but elevated heels is recommended in order to stimulate the repair process, avoid contraction of the scar and to promote elongation of the tendon. This shoe induces tendon elongation when the horse is confined to a stall or working on a hard surface (elevated heels), promoting healing in an elongated, rather than contracted, configuration. This period corresponds with the period of light exercise (walking, trotting) of the rehabilitation program.

When the lesion has completely healed and the horse is ready to begin more serious training, the wide toe and narrow but elevated heels shoe can be maintained (approximately 6-9 months after injury). But when the horse begins to work at his athletic level; flat, thin and light shoes should be used.

**PREVENTING TENDON INJURIES**

As with all orthopaedic problems, a well-balanced foot is an essential part of both the preventative and treatment components of tendon injuries. As previously mentioned, there is no doubt that long toes predispose horses to tendon injuries by altering the fetlock angle and applying additional strain on the superficial flexor tendon. This effect is compounded by low, underslung heels that creep forward and sit horizontally (instead of vertically) on the solar surface of the foot.

Tendons lose their ability to adapt to exercise after the first year of life. Thus any prophylactic exercise program designed to increase tendon strength and elasticity must be completed before the horse turns one. This does not provide a very opportune window of opportunity for intervention. However, it emphasises the necessity for the growing athletic horse to be placed in an environment where it is able and encouraged to run with the herd.

Avoiding situations that predispose the horse to fatigue is also an important preventative. Ensure that the horse is always cardiovascularly and musculoskeletally fit to perform at the required level at each stage of its training program. Advances in expected performance level should be gradual and well planned. Fatigue can be prematurely induced by heavy working surfaces such as sand arenas or tracks or rain affected surfaces. Uneven surfaces also represent a danger by placing an “unexpected load” on the tendon as the foot and fetlock sink into the pothole.

And of course, speed remains the other great predisposition. Training at levels just below maximal speed is likely to decrease the incidence of both tendon injury and recurrence.

Overweight and heavy horses place additional load on their tendons. Horses with pre-existing tendon injuries should be kept “lean and mean”. This may involve the incorporation of a strict diet regime.

A better understanding of the way tendon tissue matures and can be conditioned, the causes and nature of tendon injuries and the subsequent healing process and an array of new therapies means that a tendon injury, although still a serious concern, does not necessarily signal the end to the horse’s competitive athletic career.

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