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SADDLE SLIP MAY BE AN INDICATOR OF THE PRESENCE OF HINDLIMB LAMENESS

Introduction

We have observed saddle slip consistently to one side on some horses. Reasons include a crooked rider, an ill-fitting saddle, asymmetry in back shape and lameness. Currently, there are no objective data assessing the relative importance of each factor. The objectives were to document the frequency of occurrence of saddle slip in horses with hindlimb lameness compared with other horses and to describe the effect of lameness characteristics and grade, the abolition of lameness by diagnostic analgesia, breed, type, size, thoracolumbar shape and symmetry and the rider’s weight.

Materials and Methods

Seventy-six horses were assessed prospectively and lameness grade and degree of saddle slip before and after diagnostic analgesia were recorded. The thoracolumbar back shape and symmetry were measured objectively. In a subset of horses the pressure distribution underneath the saddle was measured before and after diagnostic analgesia to provide objective validation of the observations.

Results

The saddle consistently slipped to one side with 2 riders in 24/48 (50%) of the horses with hindlimb lameness, compared with 1/15 (0.07%) horses with forelimb lameness, 0/6 (0%) with back pain and 0/7 (0%) non-lame horses. The association between saddle slip and hindlimb lameness was statistically significant (rs 0.477 p=0.000). Diagnostic analgesia abolishing the lamenesses also eliminated the saddle slip in 24/25 horses (96%). In one horse, with an asymmetric saddle, and bilateral forelimb lameness, the saddle continued to slip after resolution of lameness. The saddle slipped to the side of the lamest hindlimb in most horses (18/24 [75%]). No horse with saddle slip had significant left–right asymmetry of the back at 4 predetermined sites.

Conclusions and practical significance

Hindlimb lameness is an important factor in inducing saddle slip. Saddle slip may be an indicator of the presence of hindlimb lameness.

Acknowledgements: The Saddle Research Trust and Biosense Medical.
The advent of the internet and new information technologies has given rise to the field of telemedicine, which enables professionals to evaluate and monitor health parameters at a distance. This form of medicine is currently provided to human medical patients, formula-one race car drivers and astronauts (among others).

Remote medical service presents a variety of advantages to the equine practitioner. These include:

1. Elimination of distance barriers
2. Reduction in the need for accessory personnel
3. Reduction in overall veterinary workload
4. Elimination of physical risk (danger) to veterinary personnel
5. Reduction in veterinary evaluation time and expense
6. Reduction in reporting turnaround time
7. Increased accessibility to a centralized pool of medical expertise
8. Ability to perform multiple evaluations within a short period of time

The dramatic increase in evaluation efficiency allows the equine veterinarian to provide an attentive, proactive approach to managing and preventing lameness. This translates into a better overall service to the client.

Telemedicine also facilitates synchronized communication between various caretakers of an individual (such as the veterinarian, owner, trainer, and farrier).

Basic process elements for remote digital assessment using Equine Tec software include:

1. Acquisition of video footage. Footage is obtained by an individual (owner, trainer, etc.) in the physical presence of the horse. Footage in standard definition and either .avi or .mov formats is preferable, although EquineTec software allows for various format conversion. Camera motion during filming is restricted to a horizontal plane; vertical movement, zooming and/or panning is discouraged as this makes subtle gait abnormalities more difficult to discern.

The following footage is requested:

A. With the horse standing squarely on a level surface: dorsal views of the thoracic feet and limbs together, plantar views of the pelvic feet and limbs together, lateral views of each thoracic and pelvic foot separately and right and left lateral views of the entire animal.

B. With the horse moving on a hard (e.g. asphalt) surface: cranial and lateral views of the horse walking and trotting in a straight line on a loose lead.

C. With the horse on a soft (e.g. arena) surface: lateral views of the horse at the walk, trot and canter on the lunge and under saddle.

D. History may dictate that additional (special) footage be procured.

2. Submission of video footage. Although there are numerous strategies for transferring digital information between interested parties, Dropbox® provides a free service that allows for instant large file sharing. A folder containing video footage is shared between the client, veterinarian and other related parties.
3. Loading of footage into motion analysis software. Equine Tec has integrated Drop-box® into their file management software to allow for automatic access to images within shared folders. Image selection within the software program uploads footage into a viewing panel for evaluation.

4. Digital evaluation of video footage. Once uploaded, pertinent image(s) are viewed within the motion analysis software program. The software utilizes a variety of tools that allow for thorough evaluation of footage.

5. Electronic record creation. Evaluation findings and recommendations are documented. Segments of video footage, photographs, diagrams and verbal commentary are often included in the record, which is created within the software program.

6. Sharing the results of the evaluation. Using Dropbox-integrated software, a copy of the record is published to the web. A link to the record is concurrently created and sent to authorized parties to allow for online viewing and/or downloading.

RECOGNITION AND DESIGNATION OF SPECIFIC GAIT SIGNATURES TO AID IN THE DIGITAL ASSESSMENT OF EQUINE LAMENESS.

For the better part of veterinary medical history, clinical examination was the primary tool used to diagnose lameness in the horse. Through meticulous inspection and a methodical approach, the veterinarian would formulate a visual impression of the horse's movement for the purpose of discerning clinical significance(s). Individual gait characteristics were identified and subsequently “decoded”, using previous correlations and experience obtained by the examining veterinarian. This approach to evaluation was more representative of “art” than medicine, but often allowed the practitioner to accurately interpret the relationship between specific gait abnormalities and probable sources of lameness.

Although less emphasis has been placed on the visual assessment of the lame horse pursuant to the veritable explosion of newer diagnostic and imaging modalities, clinical examination remains an essential component of thorough investigation. For the veterinarian performing remote (digital) lameness examination, it comprises the only component.

The recent development of motion analysis software has enabled equine veterinarians to accurately depict gait alterations in the lame horse, as well as facilitate the accumulation and categorization of abnormal movement patterns, individually referred to as “gait signatures”. Digital gait signatures can be used to augment clinical examination, implicate likely sources of lameness, and provide a basis for future comparison and quantification among veterinarians.
THE USE OF UTC IN PRACTICE: A GUIDED TOUR THROUGH A SERIES OF CLINICAL CASES

Introduction
In equine orthopaedics, ultrasonography is an important diagnostic tool in the detection of bony and soft tissue lesions.

Ultrasonography has a high sensitivity and is of relative low cost. Its mayor disadvantage is its operator dependency: the experience of the operator and its humility in interpreting the image is of mayor importance.

Ultrasonographic Tissue Characterisation (UTC) is a novel ultrasonographic technique in which the results of scanning tendons are less operator depended.

Technique
To be able to assess the integrity of a tendon, a three dimensional (3D) image of the tendon is build up with a specific designed scanning device (tracker). This tracker moves the ultrasound transducer along the tendon and gives a location in space to the transverse ultrasound images made every 0,2mm. This results in a 3D ultrasonographic volume containing over 600 transverse still images.

Once this volume is made, a mathematical algorithm analyzes the volume, resulting in four different tissue types. Type I are non-waving structures of >0,4mm (intact tendon-fiberbundles). Type II are waving or short structures >0,4mm (like fiberbundles of inferior repair). Type III are structures <0,4mm like fibrotic tissue. Type IV is the tissue without any detected structure (blood, fluids).

Results
Out of this mathematical calculation of the structure of the tendon, the clinician has objective structural information, in contrast with a subjective assessment of the tendon with conventional ultrasound.

During this presentation the author will demonstrate the technique. Advantages and disadvantages will be discussed and the usefulness in practice will be demonstrated. Several cases will be presented to illustrate the daily use of this recent technique.
PRACTICAL AUTOLOGOUS PRODUCT USE

Stem Cells

Stem cells are broadly defined as undifferentiated cells that are capable of self-renewal and differentiation into specific lineages, i.e. of the 3 germ layers which are the ectoderm, endoderm, and mesoderm. Stem cells are classified both by potency and type (tissue source). Multipotent stem cells are able to give rise to more than 1 cell type but are generally restricted to 1 germ layer (for example, give rise to cartilage and adipose tissue which are both mesoderm in origin), while pluripotent stem cells are to give rise to all cell types within the body from all 3 germ layers. Types of multipotent stem cells include adult-derived mesenchymal stem cells (MSCs), which are discussed below, and hematopoietic stem cells. Types of pluripotent stem cells include embryonic stem cells (ESCs) and induced pluripotent stem (iPS) cells which are both discussed below.

Adult-derived mesenchymal stem cells

Adult-derived mesenchymal stem cells (MSCs) can be obtained from bone marrow, fat, umbilical cord blood, muscle, and many other tissues including cartilage, trabecular bone and tendon. Two techniques are commonly used for the treatment of equine musculoskeletal injuries with MSCs. One relies on a cultured cell population derived from bone marrow while the other utilizes a mixed cell population derived from adipose tissue. Each technique has its strengths and weaknesses and both in vivo and clinical evidence will be discussed in the lecture.1-4

1) Bone marrow derived MSCs (BM-MSCs): BM-MSCs are chosen as they appear to perform superiorly to MSCs recovered from other tissues (including tendon) in terms of differentiation into known cell types. Furthermore BM-MSCs have received the most attention scientifically and hence are the best characterized. Bone marrow is collected from the sternum (or the tuber coxae) under standing sedation, followed by isolation and expansion of the nucleated adherent cell population (containing the MSCs) in the laboratory. A 3 week culture period is then needed to expand these selected cells until in excess of 10x106 cells are available for implantation either under standing sedation into a tendon or ligament lesion using ultrasound guidance or under general anesthesia into a cartilage defect using arthroscopic guidance.

2) Adipose-derived MSCs (A-MSCs): This technique is based on data which suggested that adipose-derived MSCs exhibited a similar degree of multi-potentiality to BM-MSCs although in many studies they perform less well than BM-MSCs in differentiation assays. The currently available technique utilizes a mixture of cells derived from the adipose tissue (taken surgically from the tail head) once the cells containing fat have been removed – there is no culture step. This has the advantage of supplying large numbers of cells (but with only an estimated 2% being MSCs) in a short period of time (48 hours). The cells are implanted as outlined above.

Embryonic stem cells and induced pluripotent stem cells

1) Embryonic stem cells (ESCs): True ESCs are derived from the inner cell mass of the pre-implantation blastocyst and have an indefinite replicative life span. As described above, they are able to give rise to all cell types of the body and are able to form teratomas when implanted into immune compromised (SCID) mice. To date, no one has been able to culture such cells from the horse; however there are equine ESC-like cells described in the literature as well as equine fetal-derived ESC-like cells. These equine ESC-like cells have some pluripotent characteristics but are unable to form teratomas in SCID mice.5-9

2) Induced pluripotent stem (iPS) cells: iPS cells are derived from adult somatic cells which have been reprogrammed using pluripotency genes back to an ESC state. Like true ESCs, equine iPS cells have an indefinite replicative life span and are able to form teratomas in SCID mice.10

All of these cells have tremendous promise for the treatment of musculoskeletal injuries in horses but are in the very early stages of investigation. An in vivo study using equine fetal-derived ESC-like cells will be discussed in the lecture.9
Platelet Rich Plasma

Platelet rich plasma (PRP) is defined as plasma with a 2 or more fold increase in platelet concentration above baseline levels or >1.1x10^6 platelets/μl. PRP is generated primarily by centrifugation or gravity filtration. There are differences in the volume of autologous blood required, time and speed of centrifugation, addition of an activating agent, leukocyte concentration, method of delivery, and qualitative/quantitative differences with respect to final PRP volume and final platelet and growth factor concentrations between the available systems. Overall, the final PRP platelet concentration is 2-8 times over baseline. It is important to recognize and understand that there are obvious differences between types of platelet concentrates that are being used, the general term/abbreviation PRP will be used herein.

The concept that PRP would improve tendon/ligament or joint disease is based on the physiologic role of platelets in wound healing. Through a modulation of the inflammatory response, promotion of local angiogenesis, attraction of fibroblasts and local stem cells to the site of injury and an induction of autocrine growth factor production by uninjured adjacent cells, platelets and their products are instrumental in normal tissue repair and regeneration. Work in our laboratory suggests that white blood cells in PRP increase tissue catabolism and decrease matrix synthesis. Data from our laboratory group indicates a positive correlation between white blood cells, predominantly neutrophils, and both IL-1 and tumor necrosis factor-α (TNF-α). These data suggest that the optimal PRP preparation would be one with the lowest white blood cell content to maximize the benefits of platelet-derived growth factors while minimizing the inflammatory and catabolic effects of white blood cells. There is presently no head-to-head comparison amongst the various PRP products, but the practitioner should ask the manufacturer not only what the platelet content is in the PRP preparation, but what the white blood cell content is as well.

Once isolated, the PRP can be injected into a tendon/ligament lesion or joint with or without an activating (clotting) agent. The addition of bovine thrombin to the PRP sample just prior to or during injection is used in some systems to activate platelets resulting in initiation of the clotting cascade. Clotted PRP serves as a fibrin matrix which serves as a scaffold for tissue repair and a reservoir for retention and slow release of growth factors. There are now numerous equine studies in the literature investigating the efficacy of PRP for tendon and ligament repair.11-15

Bone Marrow Aspirate Concentrate

Bone marrow aspirate concentrate (BMAC) is generated through centrifugation of bone marrow aspirate. The advantage of BMAC over PRP is that it contains MSCs, which have demonstrated utility for repair of tendons, ligaments, and cartilage. It is important to realize, however, that the number of MSCs in BMAC is dramatically lower than that of a cultured cell population of BM-MSCs. Like PRP, BMAC is a fully autogenous biologic that can be generated patient-side and when clotted, forms a scaffold. Also, like PRP, BMAC contains platelets and therefore is a rich source of growth factors.

In an equine model of 15mm diameter, full thickness cartilage defects, BMAC resulted in significantly improved cartilage repair compared to microfracture using short-term arthroscopic inspection and longer-term macroscopic, histological and quantitative magnetic resonance imaging analyses.16 Differences between BMAC and microfracture observed arthroscopically at 12 weeks persisted at 8 month evaluation.16 In particular, repair tissue in BMAC-treated defects was much better integrated into surrounding normal cartilage, the tissue was thicker, and had a smoother surface. Like PRP, BMAC is being used as a primary intra-articular joint injection, but no clinical data has been reported on its use.

Autologous conditioned serum/IRAP

Autologous conditioned serum (ACS) was probably the first biologic to be tested in horses. ACS is generated through the same process as IRAP, but for primarily legal reasons, it is called ACS. It is thought to act by blocking the receptor to the inflammatory cytokine interleukin-1 (IL-1). When injected intra-articularly into horses with surgically created synovitis/early arthritis, ACS resulted in decreased synovial hyperplasia and lameness compared to placebo treated groups.17 There is a newer generation of ACS termed IRAP II which boosts increased IRAP levels and is presently being tested by the equine group at Colorado State University.18
References:


5. Guest DJ, Smith MR, Allen WR. Equine embryonic stem-like cells and mesenchymal stromal cells have different survival rates and migration patterns following their injection into damaged superficial digital flexor tendon. Equine Vet J. 2010 Oct; 42(7): 636-642.


PRACTICAL CHONDROPROTECTIVE DRUG USE

When confronted with a horse suffering from acute or chronic joint disease, your therapeutic goals should be aimed at both the soft tissue supportive structures and cartilage within the joint. The joint should not be thought of as simply articular cartilage, but rather as an organ consisting of cartilage, joint capsule, ligaments, synovial fluid and subchondral bone. Your therapeutic goals may be to decrease inflammation, alleviate pain, or restore the articular environment to slow progression of disease. Your recommended therapy will likely include a combination of supportive care methods, as well as administration of pharmaceuticals and nutriceuticals.

Hyaluronan

Hyaluronan (HA) is present within articular cartilage where it is synthesized by chondrocytes and in synovial fluid where it is synthesized by type B synoviocytes. Hyaluronan can exist as hyaluronic acid, sodium hyaluronate or as hyaluronate depending on the environment in which it is found, and all terms are used interchangeably. It has been recognized for many years and in several species that in osteoarthritis (OA) the molecular weight and concentration of HA were diminished by one half to one third of their normal values, giving rise to the concept of visco-supplementation.

Hyaluronan imparts the viscoelastic nature to synovial fluid, which means it behaves as a viscous solution at low shear rates and is elastic in nature at high shear rates. In synovial fluid HA also lubricates the synovial membrane/cartilage interface (boundary lubrication) and physically excludes active inflammatory components and leukocytes from the joint cavity, a mechanism known as steric exclusion. Hyaluronan has additional direct anti-inflammatory effects and has been shown to decrease and fibroblastic pannus formation in osteoarthritic joints.

The functional mechanisms of HA are directly dependent on the molecular weight and concentration of HA. This concept should be kept in mind when choosing from the assorted preparations of HA available for use. The molecular weight of equine synovial fluid HA has been reported to range between 2-3 million daltons, while the reported concentration of HA ranges between 0.33 - 1.5 mg/ml. For the available HA products, molecular weight and price are typically directly and positively correlated. Therefore, the high molecular weight preparations are recommended due to their increased efficacy and longer duration of action.

The various HA products have excellent safety profiles. Joint flares have been reported to occur in approximately 5% of injections. Joint flares can be difficult to distinguish from joint infection in the first 24 hours and may require active treatment such as joint lavage, analgesics, NSDAI, and precautionary antibiotic administration. The clinical presentation of joint flares is typically milder than a joint infection with regard to joint swelling; lameness, synovial white blood cell count, and joint flares are self-limiting. Joint flare also occurs subsequent to the administration of steroids.

The dosing routine for hyaluronan in horses has been arrived at based on clinical impressions, and there is wide variation in how horses respond clinically to HA administration. When administered for idiopathic synovitis, HA would typically be injected IA every 3-6 weeks for 3 injections. There is no rest period required after HA administration. It is common practice to administer corticosteroids with HA. Combinational therapy of HA/corticosteroid is recommended when treating synovitis that is minimally responsive to HA alone or when treating the coffin joint, which does not appear to respond clinically as well to HA therapy as other joints. The manufacturer recommended doses are based on use in a fetlock or carpus, so when using HA in a large joint such as a stifte, one should probably administer a double dose.

Polysulfated glycosaminoglycan

PSGAG are capable of stimulating chondrocyte metabolic activity while concurrently inhibiting the effects of many enzymes involved in cartilage breakdown. PSGAGs also stimulate HA synthesis by the synovial membrane, and have antiinflammatory and analgesic properties. These beneficial effects on cartilage metabolism have been demonstrated in numerous species in both vivo and in vivo studies, and in multiple types of naturally occurring and experimental joint diseases. Despite extensive research, the exact mechanisms of action of PSGAG remain unknown.
Originally, PSGAG was designed and evaluated for IA administration. When used IA, PSGAG was administered at a dose of 250 mg weekly for a minimum of 3 weeks with good clinical results. However, it is well recognized that IA infection is potentiated by the administration of PSGAG. In order to circumvent potentially devastating iatrogenic IA infections, IM administration of PSGAG was evaluated. Following administration of 500 mg PSGAG IM, therapeutic levels of PSGAG were found in multiple joints for up to 12 hours. It is currently recommended that PSGAG be administered IM at 500 mg every 3-5 days for a minimum of 5 treatments. It is certainly safest to administer PSGAG IM, however if one is going to administer PSGAG IA, then an aminoglycoside (eg 250 mg amikacin) should be concurrently injected. While no studies have been performed to determine the effects of amikacin injection on PSGAG activity, there does not seem to be any decline in clinical responses.

**Pentosan polysulfate**

Pentosan polysulfate (PPS) was initially used in humans as an anticoagulant, then as an antiinflammatory, and most recently as the major treatment for interstitial cystitis. PSS is made from beechwood shaving and is inexpensive. Both the sodium (NaPSS) and calcium (CaPSS) forms exhibit a wide range of pharmacological activities, with CaPSS reported to have greater bioavailability than NaPSS. PPS stimulates chondrocytes to synthesize new cartilage matrix and inhibits multiple degradative enzymes and inflammatory mediators, thereby attenuating catabolic events responsible for the loss of cartilage matrix in OA joints. There is substantial evidence that PPS can stimulate the synthesis of HA by synoviocytes and stimulate the release of tissue plasminogen activator, consequently increasing fibrinolysis with resulting improvement in synovial membrane and subchondral blood flow.

**Nutraceuticals**

There are numerous components recommended in the treatment of joint disease including: chondroitin, glucosamine, Perna mussel, ascorbic acid, and omega-3 fatty acids. Few have been investigated in the laboratory and in thorough clinical trials. Because nutraceuticals are not drugs, they are not regulated by government agencies in most countries. When tested, the label claims and actual components of most joint supplements do not match. The equine formulation that has been most extensively studied is Cosequin (Nutramax). That is not to say that none of the other joint supplements work, but there is no way to determine if they will. One way to determine if a nutraceutical is efficacious is to suggest that a client start their animal on Cosequin to see the maximal effect that might be obtained. They can then change to a less expensive brand and use their judgment to see if it works as well. Cosequin does have the two disadvantages: 1) it is expensive and 2) is only obtainable through a veterinarian.

**Tetracycline family antimicrobials**

Tetracycline antimicrobials such as minocycline and doxycycline have long been advocated as treatments for rheumatoid and OA in humans. Clinical signs of improvement attributed to tetracycline therapy include decreased joint pain and suppressed progression of articular cartilage erosion. In equine practice, horse owners frequently report that their lame horse became sound and “never went better” when placed on doxycycline pending test results for Lyme Disease, despite the fact that the vast majority of those horses tested negative for Lyme Disease. The effectiveness of oral doxycycline and minocycline in the treatment of OA is due at least in part to the ability of tetracyclines to reduce matrix metalloproteinase (MMP) activity with joints through binding of the divalent cation zinc which is required to convert pro-MMP to active MMP.

In our laboratory, in vitro and in vivo studies were performed to assess the capacity for doxycycline and minocycline to alleviate cartilage degradation associated with treatment of catabolic mediators interleukin-1 (IL-1) and matrixmetalloproteinase-13 (MMP-13). Our studies indicate that both doxycycline and minocycline exert their primary effect on the synovium which in turn results in protection of the articular cartilage from the degradative effects both catabolic mediators IL-1, and MMP-13. Interestingly, our in vivo studies show that doxycycline accumulates in the synovial fluid to a greater extent than minocycline. Current studies are being performed to determine the minimal dosing regimen needed to achieve anti-inflammatory, but not antimicrobial levels in synovial fluid. The long term effects of low-dose doxycycline on antimicrobial susceptibility and photosensitization are unknown, but there are studies of people on long...
term, sub-antimicrobial doses of doxycycline and minocycline with rare side effects reported. Tetracycline antibiotics are highly plasma protein bound and should not be administered in conjunction with other highly protein bound drugs such as phenylbutazone.

With any of the chondroprotection medications, it is important to assign a rehabilitation program that includes corrective trimming/shoeing, a detailed exercise program, and weight loss if necessary in order to achieve maximal success.

References:

2. Fortier LA, Motta T, Greenwald RA, Divers TJ, Mayr KG. Synoviocytes are more sensitive than cartilage to the effects of minocycline and doxycycline on IL-1 and MMP-13 – induced catabolic gene responses. JOR 2010; 28:522-528.
REGENERATIVE STRATEGIES FOR THE TREATMENT OF EQUINE TENDON LESIONS

There are many unanswered questions surrounding the therapeutic use of stem cells in horses. While no treatment paradigms have been described, this lecture will provide general recommendations for the current treatment of equine tendon lesions. In addition to stem cells, the use of platelet rich plasma for the treatment of tendon lesions will also be discussed.

Treatment of discrete core lesions

- Stem cells should be injected directly into the lesion under ultrasound guidance.
  - Use of a 20 or 23 gauge needle is recommended for direct injection based on work from our laboratory in which the use of smaller gauge needles resulted in decreased cell viability presumptively due to cell shearing.

Treatment of diffuse lesions or multiple lesions within the same limb

- Administration of stem cells via intravenous regional limb perfusion should be considered based on a recent study by Sole et al. (2012).
  - Either intravenous catheters or butterfly needles size 20 gauge or larger are recommended for this technique for ease of slow administration and to avoid decreased cell viability as discussed above.
  - As reported by Sole et al. (2012), intra-arterial regional limb-perfusion should be avoided at this time due to the potential for arterial thrombosis ([628 Sole, A. 2012]).

Follow-up/Rehabilitation protocol

- Common in clinical practice to perform multiple injections depending on healing of the injured tendon.
  - Recheck examination of the horse at 30 days post initial injection and repeat treatment if less than fifty percent improvement in both the degree of lameness and ultrasonographic evaluation findings.

- Rehabilitation protocol tailored to each individual horse according to physical examination and lameness evaluation findings in conjunction with ultrasonographic findings.
  - Provide owners with instruction only until the time of the horse’s next recheck examination with specific but gradual increase in exercise as opposed to box stall rest.

Unknowns

- Range of stem cell numbers has been described in the literature for therapeutic application with the most common being 10x106 BM-MSCs per tendon lesion.
  - It is likely that a range exists within which stem cell numbers are most effective.
  - Dose-dependent response studies are needed in the horse to determine this range.
  - Potential benefit of simultaneous therapy with PRP or other biologics.
  - Chemotactic properties of PRP to recruit endogenous stem cells being investigated by our laboratory and others.

References:


REGENERATIVE STRATEGIES FOR THE TREATMENT OF EQUINE INTRA-ARTICULAR LESIONS

There are many unanswered questions surrounding the therapeutic use of stem cells in horses. While no treatment paradigms have been described, this lecture will provide general recommendations for the current treatment of equine intra-articular lesions. In addition to stem cells, the use of platelet rich plasma (PRP), bone marrow aspirate concentrate (BMAC), and autologous conditioned serum/IRAP for the treatment of intra-articular lesions will also be discussed.

Treatment of osteoarthritis (OA)
- Stem cells can be injected intra-articularly either alone or in conjunction with products routinely used to treat OA.
- Inject stem cells on as needed basis as would be performed if using corticosteroids.
- In the absence of surgery, horses are returned to exercise after 24 hours similar to more routine treatment with corticosteroids and/or chondroprotective agents.

Treatment of cartilage defects (surgical)
- Stem cells or BMC can be grafted into a lesion under arthroscopic guidance. This requires:
  - Use of gas arthroscopy.
  - Dual syringe injection system in which the cellular component is in one syringe and bovine thrombin is in the other syringe.
  - Alternatively, autologous or commercial fibrin can be used to retain the cells.
- Following a grafting procedure, a rehabilitation protocol is established and is largely dependent on the size, location, and nature of the cartilage defect:
  - Young horses treated for osteochondritis dissecans (OCD) lesions are generally confined to a box stall for 2 weeks post-operatively, following which time gradually increasing amounts of hand walking are initiated. At 3 months post-operatively, a veterinary examination is performed and radiographs of the affected joint are taken and evaluated for healing prior to small paddock turnout for an additional month and then full turnout for another 2 months. Veterinary examination and radiographs at 6 months postoperatively are then used to determine if the horse can start training.

Treatment of cartilage defects (non-surgical)
- Stem cells can be injected intra-articularly for the treatment of cartilage defects.
- Adult horses treated for traumatic lesions without surgery, may start handwalking as early as 7 days post-injection and are evaluated at 1 month post-injection to further define an exercise protocol dependent on the particular horse, the type and magnitude of articular damage, and the horse’s discipline.

Unknowns:
- Optimal number of MSCs for the treatment of OA and cartilage defects is unknown as no dose response studies have been performed to date.
  - Published studies most commonly use a range of 10×10⁶ to 15×10⁶ BM-MSCs per joint/cartilage defect, cell numbers can be larger, particularly for the grafting of large defects.
- Possible benefit of simultaneous therapy with PRP or other biologics.

References:


Towards a better understanding of the biomechanics of the equine distal limb

The equine distal limb and associated lameness problems will occupy a large proportion of a veterinary surgeon’s time, in particular, lameness problems of the digit and the fetlock joint. Over the past 5-10 years, knowledge of the anatomy of the distal limb has advanced considerably with the development of advanced imaging techniques. During the same time, more advanced computing facilities, accelerometers and high speed video cameras have facilitated research relating to the biomechanics of the distal limb, the foot and the metacarpophalangeal joint (MCPJ), in particular. These advances have provided us with a better understanding of the movements of, and forces acting upon the distal limb. The technology has advanced to the point that the foot-ground interaction can be studied in the laboratory and in the horse’s normal working environment. The insights gained from these studies are beginning to inform our veterinary treatments as well as the design of the surfaces upon which horses perform. A better understanding of the biomechanics of the distal limb will inform our understanding of the aetiology and therefore, the potential treatments of common lameness problems.

Functional anatomy

The anatomy of the equine digit is unique and has evolved to enable the horse to move quickly and efficiently. As we consider the different anatomic structures, their intimate interactions must be understood in order to understand how this relatively small structure can function to support a large, rapidly applied load. One of the features that is unique to the equine digit is the arrangement of the laminae, in particular, the presence of secondary lamellae which increase the surface area of attachment between the bony column and the keratinised epidermal tissue of the hoof horn. In addition, the lamellar structure allows the third phalanx (P3) to remain within the hoof capsule when the loading of the limb pushes P3 distally. The digital cushion and collateral cartilages function to dissipate the large Newton loads that are experienced by the foot. The tensile pull of the DDFT helps to counter the ground reaction force while storing elastic energy during stance to assist in propulsion forward at the point of break-over. Overall, the hoof capsule and the internal structures are designed to absorb and dissipate a large portion of the load applied to the digit during equine locomotion.

Biomechanics of the equine digit

The equine stride is divided into two main phases: swing and stance. The swing phase is the aerial phase which begins when the toe of the hoof leaves the ground at the end of break-over and ends with ground contact. During this phase, the limb usually moves from a retracted and predominately flexed position, to a proracted and predominately extended position. Minimal lameness problems are attributable to the swing phase. Therefore, there is less research relating to this phase compared to the stance phase.

The stance phase is the period of the stride from impact of the foot on the ground to the end of break-over, or toe-off. The stance phase of the stride can be divided into impact, stance and break-over with each phase having separate sections. The impact phase is often observed carefully at the walk when foot balance is assessed; however, the naked eye is not capable of appreciating or measuring the different phases of impact. At slower speed, impact is often toe first; however, at the faster gaits of trot, canter and gallop, impact is primarily heel first. Impact consists of the initial striking of the heel on the ground, at which point the foot begins to decelerate while the heels slides along the surface. The foot slips with only heel contact for 3-5 milliseconds (ms) before there is contact of the entire foot with the ground, after which sliding continues with the entire foot for an additional 15 – 20ms. These phases of impact can be referred to as heel slide and foot flat slide.

When the foot is flat and has stopped sliding, the limb becomes relatively stationary in position while the mass of the body continues forward over the foot. This is the period during which large loads are experienced throughout the distal limb. At the end of stance, the break-over phase begins with lifting of the heel before lifting of the toe. Depending on the surface on which the horse is working and the type of shoe on the foot, there may be some palmar/plantar movement of the toe during this phase of the stride.
**What forces act on the equine digit during stance?**

During the stance phase, the digit is subjected to multiple forces. The primary forces are the ground reaction forces, which account for the weight of the horse pushing down and the equal and opposite force of the ground pushing back. This ground reaction force is usually measured with a stationary force plate, but more recently GRF has been measured with force plates mounted below treadmill belts and with instrumented shoes. The GRF has three main components: vertical, horizontal and transverse, with each component having a direction and magnitude. The vertical GRF measures the force applied due to the weight of the horse's body as the limb is loaded with the peak force in mid-stance when the third metacarpal/metatarsal bone is perpendicular to the ground. The horizontal or longitudinal GRF is the result of friction between the hoof and the ground. The horizontal GRF describes the deceleration of the foot from impact to the start of stance and the acceleration force experienced during the propulsion portion of the stance phase. The beginning of the horizontal GRF is a period in which the force does not increase smoothly, appearing to have an oscillatory pattern. The horizontal GRF is affected by the amount of foot slip occurring before the foot stops moving in a forward direction, so horizontal GRF may vary considerably with surface and shoeing. For instance, the presence of toe grabs or studs in the shoe may limit sliding of the foot (Harvey 2011), likely altering the biomechanics of the digit and the ability of the foot to dissipate the force of impact. The transverse component of the GRF is the lowest in magnitude and varies from being larger medially at walk and laterally at the trot. Force plate measurements are usually made on a flat, firm surface on which the transverse component of GRF may be small. The development of instrumented shoes will enable us to better describe the transverse GRF when the horse works on the more common ménage surface, racetrack or grass arena.

Centre of pressure (COP) is a term used to describe the geometric centre of the weight-bearing surface of the foot. The COP can be altered by trimming and shoeing. In general, the COP is at the heels on impact, moves dorsally to the area of the tip of the frog during stance and then moves forward to the toe region of the sole during foot off.

**What dynamic alterations occur within the hoof capsule during stance?**

The equine digit is designed to absorb the forces of impact and has an essential role in the dissipation of forces transmitted through the limb. The anatomic arrangement of the third phalanx, the deep digital flexor tendon, the laminae, the hoof wall and the digital cushion allow for absorption of the concentrated, multidirectional and high forces applied to the digit, often repeatedly and at high speeds. There is a downward force from the second phalanx onto the third phalanx as a result of the horse's body mass. A proximalpalmar tensile force is acting on the solar surface of P3 in the region of insertion of the DDFT. When the DDFT is under extreme tension during loading, the DDFT also acts to apply an upward pressure on the navicular bone (distal sesamoid bone) which meets the downward force of P2. As P3 is forced distally, there is an opposite upward force around the periphery of P3 as a result of the laminar attachments which maintain the attachment of P3 to the inner hoof capsule. Adding to these forces is the upward force through the solar surface (sole, frog and heels) which is equal and opposite in response to the GRF.

The intricate arrangement of the laminae, laminar vasculature and the hoof wall play a significant role in the dissipation of these forces within the foot. During loading, the hoof wall appears to undergo compression at the toe from impact to mid-stance, with expansion at the quarters. The ground reaction force pushes upwards through the sole and the frog causing the heel expansion through an outward pushing of the lateral cartilages due to pressure on the digital cushion. This expansion damps and begins to dissipate the force of impact. The blood vessels on the inner margin of the lateral cartilages undergo cyclic compression with locomotion, which assists with the pumping of blood proximally from the digit. Overall, the equine digit has a pervasive network of large and small vessels which anastomose throughout the digit. The nature of the vascular network is best visualised on a venogram of the digit. These multiple vascular networks are thought to play a role in the damping of force during impact and stance.
Biomechanics of the metacarpophalangeal joint

When considering the biomechanics of the equine distal limb, the foot and the MCPJ/MTPJ must be discussed in combination, as both have a major role in the dissipation of force with locomotion. Consider the MCPJ during stance. At impact, the MCPJ is in a position with MC3 and P1 dorsal cortices in alignment, or a neutral position. From impact to mid-stance, the MCPJ rapidly hyperextends as a result of the force of MC3 pushing distally. Initially, the SDFT, DDFT and suspensory ligaments elongate to absorb the energy; however, they rapidly reach close to their limit of strain at mid-stance. At the limit of the stretch of the soft tissues, the MCPJ has reached maximum extension with the dorsoproximal margin of P1 impinging on the dorsodistal margin of MC3. Concurrently, the proximal sesamoid bones are pulled tightly against the distal condyles of MC3 due to the tensile forces on the suspensory ligament branches. There is a large body of literature that describes the effect on distal MC3 of this period of maximal hyperextension of the MCPJ, in particular in relation to osteoarthritis and fractures of the lateral condyles of MC3. The majority of kinematic and kinetic studies of the MCPJ examine the joint in the sagittal plane, i.e. when observed from the lateral aspect. These studies have demonstrated the effect of different surfaces on MCPJ extension, for example, MCPJ maximal extension is similar occurs earlier in stance phase on turf as compared to synthetic and dirt racing surfaces (Setterbo 2008).

Do we understand the effects of motion out-of the sagittal plane on the biomechanics of the digit and the fetlock?

The majority of work related to the biomechanics of the equine distal limb has concentrated on movement in the sagittal plane; however, there is a degree of out-of-sagittal plane motion that occurs in the digit and in the MCPJ. Out-of-sagittal plane motion would include any medial or lateral deviation of the bones or hoof. Motion out-of-the-sagittal plane is usually reported as movement of the distal bone relative to the more proximal bone. The medial or lateral motion is referred to as collateromotion. There is also rotation of the limb around the long axis, referred to as axial rotation (Denoix 1999). Axial rotation and collateromotion are known to occur at the fetlock and the digit, based on in vivo studies performed. The degree of each out-of-sagittal plane motion increases as the speed is increased from walk to trot (Chateau 2001, Clayton 2007a, Clayton 2007b). Large alterations to axial rotation and collateromotion can be induced by raising one side of the foot relative to the other, indicating that shoeing and natural valgus or varus deformities are likely to affect the forces placed on the limb. A recent in vitro study loaded an equine limb to the equivalent of a galloping horse and documented collateromotion and axial rotation increasing with increasing metacarpophalangeal joint hyperextension. This study also measured the strain on dorsoproximal P1 during loading and revealed a sharp increase in minimum principal and maximum shear strain at about 7000N load – between trotting and galloping. The increase in strain occurred as MCP joint extension, axial rotation and collateromotion reached their peak values (Singer 2012).

Concluding remarks

The study of the biomechanics of the equine distal limb continues to increase our understanding of the kinetics and kinematics of the important structures of the limbs. I hope that these notes, the references included and the lecture will help to clarify the nature of these studies and make the current related literature more accessible.

References and useful resources.

WHAT IS THE OUTLOOK FOR PENETRATING INJURIES TO THE HOOF?

Introduction

Penetrating injuries to the solar surface of the foot can range from inconsequential to life-threatening. The anatomical location of the penetrating injury is a major determining factor in the potential outcome, since outcome is related directly to the importance of the structures that lie proximal to the area of the penetration. Penetrating injuries in the region of the middle third of the frog and the frog sulci require the most aggressive investigation and treatment, since the underlying structures include the deep digital flexor tendon, the navicular bursa and the distal interphalangeal joint. A recent multicentre study has shown that despite aggressive treatment of these injuries, the outcome is only fair for life and poor for return to athletic function.

Important features of the clinical presentation

One of the most important features of clinical presentation is the location of the penetrating injury on the solar surface of the foot, followed by the diameter and length of the offending object. The central third of the foot, in particular, the central third of the frog region presents the most dangerous area for a horse to sustain a penetrating injury. Penetrating injuries to the solar surface within 1 cm of the white line, will usually affect the underlying sole, solar corium and possible the margins of the third phalanx. Similarly, penetrating injuries in the dorsal third of the sole are less likely to have penetrated any synovial structures, but frequently contact the third phalanx, producing a focal area of bone necrosis or sequestrum formation. Penetrating wounds to the palmar/plantar one third of the hoof surface are likely to penetrate the spongy frog and the underlying digital cushion. If the penetrating object in the palmar/plantar one third of the frog is longer than 4-5 cm, then the digital flexor tendon sheath is more likely to be involved.

The primary danger zone for penetrating injuries is the middle one-third of the frog and the adjacent frog sulci, due to the close proximity between the solar surface of the foot and the vital structures of the deep digital flexor tendon (DDFT), navicular bursa, navicular bone, distal sesamoidean impar ligament (DSIL) and the distal interphalangeal joint (DIP). The distance between the depth of the frog sulci and the navicular bursa can be less than 1 cm in many horses, indicating that even a relatively shallow penetrating tract is capable of entering these vital structures. When a penetrating injury involves, the navicular bursa and the distal interphalangeal joint, synovial sepsis is the consequence, a situation that requires prompt and aggressive treatment in an effort to preserve the horse’s life and potential athletic career. The time between the occurrence of the penetrating wound and treatment was not thought to influence outcome; however, a recent study has shown that prompt treatment has a positive influence on the outcome for life and for return to athletic function.

Clinical evaluation

The traditional approach to penetrating wounds to the digit includes: paring of the foot, aseptic preparation of the foot and excavation of the external tract. These steps are usually followed by acquiring plain radiographs and then additional radiographs with a probe or contrast material in the tract. Although placing a probe in the tract can be useful, there is a chance of introduction of foreign material into the tract or pushing any contamination that is present further into the tract. Synoviocentesis of the navicular bursa and DIP joint is indicated to determine if either or both of these structures are involved. Depending on the location of the tract, the length of the penetrating object and the clinical examination, synoviocentesis of the digital flexor tendon sheath (DFTS) may also be indicated. Placement of contrast material into the synovial structures can sometimes reveal a connection between the synovial structure and the penetration tract, without the risk of pushing contamination into a vital structure or further into the tract. The above is the logical sequence of investigation for a penetrating injury to the foot; however, with the availability of standing low field MRI machines (Hallmarq) some of this process can be circumvented.

The availability of a standing low field MRI machine can expedite evaluation of cases of foot penetration and will provide superior information to radiographic examination. Preparation of the foot remains essential. A series of MRI scans (primarily T1- and T2-
weighted), in the frontal, sagittal and transverse planes can often be acquired in under an hour, often in less time than would be required for the conventional evaluation. These MRI images will provide excellent information regarding the exact location and depth of the penetration, as well as providing an indication of the presence of synovial cavity distension. Much of the uncertainty regarding involvement of the DIP joint, navicular bone and impar ligament can be resolved with this approach. Much peace of mind can be gained, particularly when the MRI images demonstrate a lack of involvement of the synovial structures. The information is extremely useful in surgical planning and in client communication as regards structures involved and prognosis.

If surgery is required, then synovial fluid samples can be taken when the horse is anaesthetised. This provides a more aseptic environment for sampling and less risk to the operator. Synovial sampling for white blood cell count, total protein, cytology and culture can then be followed directly by arthroscopic lavage for treatment.

**Treatment**

Treatment of the penetrating tracts in the dorsal or palmar one third of the foot and the entire solar rim would likely consist of preparation of the foot, debridement of the tract and radiographs. Bandaging with some topical antimicrobial would be required. Systemic antimicrobial and analgesic medication would be decided on a case specific basis.

If synovial involvement and contamination is suspected, then aggressive treatment with arthroscopic lavage of the synovial structures involved is recommended. The penetrating tract would undergo debridement with the resulting enlarged tract being used as a portal for debridement within the navicular bursa, when required. Intravenous regional perfusion with antibiotics is often undertaken at the conclusion of the surgical procedure and repeatedly over the following days.

**Outcome**

The early case series that reported treatment of penetrating injuries to the navicular bursa reported a poor survival rate of about 30% following a “streetnail” procedure (Richardson 1986, Steckel 1989). The “streetnail” procedure which involves creating a window through the frog and the DDFT into the navicular bursa, is rarely used when arthroscopy is involved. The first report of endoscopic lavage of the navicular bursa for treatment of sepsis (Wright 1999) reported a success rate of 75%. A recent multicentre retrospective study reports that 56% of horses survived to discharge from the hospital with 36% of all horses returning to their previous level of athletic function (Findley 2013). The recent study found different success rates for different types of horses and for the different hospitals in the study, indicating that these features may influence the success rate of treatment.

**References**

**TENOSCOPY OF THE DIGITAL FLEXOR TENDON SHEATH**

The digital flexor tendon sheath (DFTS) is a complex synovial cavity housing the digital flexor tendons and their associated plicae, mesotenons, manicae and vinculae, as they pass through the fetlock canal, of which the palmar/plantar annular ligament (PAL) constitutes the palmar/plantar border.

**DFTS Tenoscopy**

Tenoscopy was first described by Nixon 1 and further description given by 2. Tenoscopy has enabled recognition of previously unreported conditions, and stimulated development of therapeutic surgical techniques. Surgery is usually performed in lateral recumbency with the affected limb uppermost, and an Esmarch bandage and tourniquet applied. Initial evaluation is performed through a portal between the PAL and proximal digital annular ligament, which offers the most comprehensive, single portal evaluation. Instrument portals are made according to lesion location, avoiding where possible the annular ligaments and neurovascular bundle. The following represents experiences with 293 cases from a single referral hospital (Smith and Wright 2013 - unpublished data) and is an expansion of previously published material 3.

**Marginal tears of the flexor tendons**

Tears of the flexor tendons were identified in 57% of DFTS, and usually were primary lesions. Disruption of the deep digital flexor tendon (DDFT) was found in 140 (47%) and the superficial digital flexor tendon (SDFT) in 31 (10%) horses. Sixty-one percent DDFT tears affected the lateral margin proximal to the sesamoidean canal. The majority commenced proximal to the manica flexoria (MF) and extended varying distances distally. Depth varied between superficial disruption and deep clefts. In 42% cases focal granulomata were present at the proximal and/or distal margins of the tear. There was approximately 2:1 ratio of forelimbs to hind-limbs.

Marginal tears of the SDFT occurred most frequently between the MF and sesamoidean canal. Only the dorsal surface of the branches of insertion of the SDFT are intrathecal and tears at this site were less common.

Treatment consisted of removal of disrupted, extruded tendon fibrils with debridement of the underlying defect, using a motorised synovial resector with suction, aimed to reduce the surface area of exposed disrupted collagen. Large bundles of torn fibrils and granulomata were dissected free with meniscectomy knives and/or scissors before removal with Ferris Smith arthroscopic rongeurs.

**Tears of the MF**

Torn MF was the second most commonly identified intrathecal lesion (28% cases); 85% of these occurred in hind-limbs. Disruption was complete in 71% cases and partial in 29%; 37% of tears were medial, 29% lateral and 15% proximal and/or biaxial. Completely torn MF were resected ‘in toto’ while both complete and subtotal resections were performed on partial tears as determined by the extent of disruption.

**Tearing of the sheath wall**

The sheath wall was torn in 30% cases, but as the primary lesion in only 14%. This was most common at the proximal reflection (83%) and was frequently associated with asymmetric proximal out-pouching which became exaggerated when the sheath was maximally distended. Palmar disruption involving the mesotenon of the SDFT was the second commonest site (14%), predicted by the thickening of this structure ultrasonographically and presence of free fluid palmar to the sheath reflection from the SDFT i.e. out-with the normal sheath confines. Treatment in these cases followed the basic principles of removal of disrupted collagenous tissue in order to reduce synovial irritation and promote second intention healing.
Outcome

Greater than 1-year follow-up is available for 66 horses with tears of the DDFT. Forty-seven percent were sound with 38% returned to their previous level of work. Tears were classified according to length; 74% of short tears were sound with 63% returning to previous level of work, compared to 28% and 18% of long tears respectively. Additional significant negative prognostic indicators included the duration of clinical signs prior to surgery and the presence of marked pre-operative distension. When compared to other causes of tenosynovitis, marginal tears of the DDFT carried a significantly worse prognosis. Eighty-four percent of cases with tears of the MF were sound, with 78% working at their pre-operative level.

Two additional case series have been published detailing experiences in other hospitals with tears of the digital flexor tendons and MF. Data is similar to the above, but with a notable lower frequency of MF tears in the former series. This series was from continental Europe rather than the UK and consisted predominantly of Show-jumpers and Dressage horses as opposed to the UK series which include a greater proportion of general purpose animals. Findlay et al. reported an over-representation of Cobs and ponies, reflecting our experiences.

PAL desmotomy

The contribution of PAL desmotomy remains a point of debate. Evidence has not been produced to support desmotomy, with no significant improvement in outcome reported in cases from a single hospital where a change was made from routinely performing desmotomy, to performing only in chronic cases or where the PAL was thickened. However, desmotomy creates more space within the fetlock canal for manoeuvrability of the arthroscope and instruments, making surgical manipulations easier to perform. In addition, complications related to desmotomy appear infrequent. However, in the authors experience adhesions can develop between the desmotomy site and the SDFT, and lameness often is greater and persists for longer following desmotomy. The author therefore performs desmotomy only when there is desmitis of the PAL, or subjectively at surgery there is a restriction of space within the fetlock canal such that surgical manipulations are restricted and risk of iatrogenic damage is increased.

References

MANAGEMENT OF INTRA-SYNOVIAL TENDINOPATHIES - CURRENT STATE OF KNOWLEDGE AND METHODS OF TREATMENT

Def: Intrasynovial tendinopathy - peripheral injury with marginal (epitenon) disruption

Aetiology

Common clinical features contrast with extrathecal injuries: Intrasynovial injuries appear not to be related to speed (and presumably high strain and strain rate), with racing breeds underrepresented. There is much lower bilateral affliction, suggestive of a lesser role of preceding degeneration. Peripheral rather than central location of injuries, and high incidence in compressive (vs tensile) regions are suggestive of a different mechanism of injury. Structural and mechanical features logically are contributory.

Clinical features

Common presenting signs include lameness, synovial distension and variable heat and pain on palpation. Current state of knowledge comes from observations from clinical case series. The anatomic regions most commonly affected are the digital flexor tendon sheath (DFTS) and navicular bursa (NB). Other less common locations include the carpal extensor sheaths, tarsal sheath of the lateral digital flexor tendon, bicipital bursa, calcaneal bursa, and long digital extensor sheath. The deep digital flexor tendon (DDFT) is more commonly injured than the superficial digital flexor tendon (SDFT), although the manica flexoria is frequently injured within the DFTS.

Diagnostic Imaging

Ultrasoundography is currently most useful for assessment. Common non-specific features include sheath wall and mesotenon thickening, and intra-synovial deposits of echogenic debris. Identification of the primary lesion is often possible, although diagnostic accuracy is commensurate to experience of the imager. Critical evaluation of lesion predictability lesions is confined to the DFTS; for tears of the DDFT, PPVs of 71% and 90% and NPVs of 55% and 37% have been reported.

Ultrasonography is limited for DDFT injuries within the navicular bursa due to the hoof capsule, and MRI has evolved into the most useful modality. From cases in a clinical setting, a PPV of 79% and NPV 64% has been reported. Radiography is infrequently contributory, although dystrophic mineralisation may occur in chronically injured tendons. Positive contrast radiography is a long established technique, but more recently with knowledge gained from tenoscopic observations, the diagnostic value has been redefined for the DFTS. Due to the (relative) limitations of ultrasonography and requirements for user expertise, contrast examination provides complementary diagnostic information.

Treatment Aims

i. resolution of lameness - as opposed to extrathecal tendinopathies, where clinically limiting factors are quality of repair, level of performance attained following injury and rate of re-injury, intra-synovial injuries present with persistent lameness limiting to performance.

ii. promote tendon healing - research into intrasynovial tendon healing has focused on transection models, and although information can be extrapolated, relatively little is known specifically regarding healing of intrathecal tendon tears. Endoscopic evaluation of cases presenting with chronic complaints has identified limited healing of tears, with granulomatous caps overlying clumps of disrupted tendon. Intrasynovial adhesion formation between disrupted tendon and any other intrasynovial surface is relatively common. Tenoscopic debridement removes disrupted tissue from the surface of tears, facilitating second intention healing. In a limited number of second look endoscopic procedures, following debridement formation of an inert scar over the injured area can occur.

In the acute phase following injury, medical management is appropriate, including counter-pressure bandaging, cold and anti-inflammatory therapy. Subsequent treat-
ment should be determined by clinical response and results of diagnostic imaging.

Synovial draining and medication is commonly employed in clinical practice, most often with corticosteroids. Treatment is symptomatic only. Critical evaluation is limited to the navicular bursa, where good short but poor medium and long-term results have been reported 5,6.

Tenoscopic debridement combined with a suitable rehabilitation program, currently is considered the treatment of choice for intrathecal tendinopathies. Following surgical debridement, horses frequently are able to attain pre-injury levels of performance, although this is dependent on lesion location and extent. Re-injury is less common than for extrathecal tendinopathies, but still occurs with reasonable frequency.

The role for intra-thecal mesenchymal stem cells as an adjunct to surgical debridement has been explored in limited numbers of clinical cases, and considering outcome for extensive DDFT tears further refinement of treatment is necessary. Critical evaluation of their contribution is lacking both experimentally and clinically, although promotion of tendon regeneration as opposed to development of an inert scar is an attractive goal.

Surgical repair of lesions is another area of potential value for treatment of extensive injuries, although poor outcomes with open surgery suggest development of endoscopic techniques are required.

Injury prevention

It is currently uncertain if there are preceding degenerative changes, although this is common in rotator cuff tears in man, which have similarities to intrasynovial tendinopathies in the horse. Determination of whether such changes precede injury, and if so how their development can be limited is an area of future research.

References

Table 1: Clinical data for horses with endoscopically confirmed tendinopathy of the DDFT or SDFT within the DFTS and NB

<table>
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<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Number of horses</td>
<td>101</td>
<td>221</td>
<td>91</td>
<td>413</td>
</tr>
<tr>
<td>Age (years)</td>
<td>(n = 101)</td>
<td>(n = 114)</td>
<td>(n = 91)</td>
<td>(n = 306)</td>
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<tr>
<td></td>
<td>1-18 (mean 9.2)</td>
<td>3-29 (mean 10.7)</td>
<td>5-15 (mean 10.5)</td>
<td>1-29 (mean 10.15)</td>
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<td>Lame at presentation (%)</td>
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<td>(n = 117)</td>
<td>(n = 91)</td>
<td>(n = 301)</td>
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<td></td>
<td>78</td>
<td>98</td>
<td>100</td>
<td>93</td>
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<td>Bilateral injuries (%)</td>
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<td>(n = 221)</td>
<td>(n = 91)</td>
<td>(n = 414)</td>
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<tr>
<td></td>
<td>3</td>
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<td>14</td>
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<td>227</td>
<td>103</td>
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<td>115</td>
<td>259</td>
<td>105</td>
<td>479</td>
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<tr>
<td>Affected structure (%)</td>
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<td></td>
<td></td>
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<tr>
<td>- DDFT</td>
<td>88</td>
<td>60</td>
<td>100</td>
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<td>- SDFT</td>
<td>19</td>
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<td>12</td>
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</tr>
<tr>
<td>- MF</td>
<td>4</td>
<td>37</td>
<td></td>
<td></td>
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<tr>
<td>Outcome (%)</td>
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<td>(n = 99 / 94)</td>
<td>(n = 84)</td>
<td>(n = 183 / 276)</td>
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<td>63</td>
<td>65</td>
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<td>Previous level performance</td>
<td>38</td>
<td>52</td>
<td>44</td>
<td>45</td>
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<td>Re-injury rate (%)</td>
<td>not recorded</td>
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<td>(n = 52)</td>
<td>(n = 129)</td>
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<tr>
<td></td>
<td></td>
<td>13 / 14</td>
<td>19</td>
<td>16 / 16</td>
</tr>
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</table>

(after horses had returned to work; only those with >12month follow-up)
(same leg / incl. contralat)
Table 2: Clinical data for horses with endoscopically confirmed tendinopathy of the DDFT within the DFTS and NB

<table>
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<td>Number of tears</td>
<td>91</td>
<td>140</td>
<td>105</td>
<td>336</td>
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<tr>
<td>Forelimb (%)</td>
<td>81</td>
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<td>103</td>
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<td>Hindlimb (%)</td>
<td>19</td>
<td>37</td>
<td>0</td>
<td>21</td>
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<tr>
<td>Lesion location (% tears)</td>
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<tr>
<td>Lateral border</td>
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<td>4</td>
<td>0</td>
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<td>n/a</td>
<td>-</td>
</tr>
<tr>
<td>Long</td>
<td>52</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth of tear (% tears)</td>
<td>not recorded</td>
<td>not recorded</td>
<td>(n = 105)</td>
<td>-</td>
</tr>
<tr>
<td>Deep / extensive</td>
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<td></td>
</tr>
<tr>
<td>Shallow / small</td>
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<tr>
<td>Outcome (%)</td>
<td>not recorded</td>
<td>(n = 63 / 58)</td>
<td>(n = 84)</td>
<td>(n = 147 / 240)</td>
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<td>Sound &amp; working</td>
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<td>63</td>
<td>59</td>
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<td>Previous level performance</td>
<td>34</td>
<td>44</td>
<td>40</td>
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<tr>
<td>Short / small tears (%)</td>
<td>no influence on outcome</td>
<td>(n = 25 / 22)</td>
<td>(n = 28 / 26)</td>
<td>(n = 53 / 48)</td>
</tr>
<tr>
<td>Sound &amp; working</td>
<td>72</td>
<td>75</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Previous level performance</td>
<td>59</td>
<td>58</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Long / extensive tears (%)</td>
<td>no influence on outcome</td>
<td>(n = 29 / 18)</td>
<td>(n = 51 / 50)</td>
<td>(n = 80 / 68)</td>
</tr>
<tr>
<td>Sound &amp; working</td>
<td>28</td>
<td>53</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Previous level performance</td>
<td>28</td>
<td>34</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Re-injury rate</td>
<td>not recorded</td>
<td>(n = 39)</td>
<td>(n = 52)</td>
<td>(n = 91)</td>
</tr>
<tr>
<td>(after horses had returned to work; only those with &gt;12month follow-up)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(same leg / incl. contralat)</td>
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INVESTIGATION AND MANAGEMENT OF WOUNDS ASSOCIATED WITH SYNOVIAL CAVITIES

Synovial contamination is characterised by acute synovitis, an influx of leukocytes, inflammatory proteins and inflammatory mediators. Infection is established once bacteria have colonised the synovial membrane and started to reproduce. Infection induces a catabolic synovial state, with generation of pannus and destruction of articular cartilage, tendons and ligaments.

Assessment

Most horses with synovial infection are severely lame, although this may be less in the acute phase, or with open and draining wounds. Other influencing factors include injury to associated structures (e.g. tendon laceration, fracture/fragmentation) and recent administration of NSAIDs.

Common clinical findings include heat, pain, distension and local venous engorgement. Wounds may be remote from a synovial cavity when the horse is weight bearing, but directly overlying with the leg flexed, such as is common at the time of a kick injury. Synovial fluid may be observed draining from the wound, and this will be viscous and form a string between your fingers.

Diagnostic Imaging

Radiography should be performed routinely. Features which may be identified include foreign material, fractures/fragmentation, osteitis/osteomyelitis and intrasynovial gas. Ultrasonography often complements radiographic assessment, although wounds may limit diagnostic value due to associated gas preventing penetration of the ultrasound beam. Ultrasound may identify foreign material, tendon or ligament pathology, intra-synovial gas and osteochondral defects.

Synovial fluid analysis

Synoviocentesis should be performed remote to the wound and from areas of cellulitis. Visual assessment of synovial fluid often allows identification of contamination/infection, but sanguinous samples present more of a diagnostic challenge. Synovial fluid analysis typically reveals elevation of total protein above 20g/l (and often >40g/l) and total nucleated cell counts in excess of 50x10⁹/l. Differential counts consist of predominantly neutrophils (>80% in majority of cases) ¹,²

Confirmation of infection requires positive culture from synovial fluid, although this is associated with a 24-48 hour delay and culture rates are often dissapointing even with the use of enrichment media. Recently superior results have been obtained with an automated blood culture media enrichment system (79% positive culture) without the same delay ¹. Limitations of recovery rate, particularly when multiple organisms are likely involved, and the transfer of in vitro to in vivo sensitivity must be considered when interpreting results.

Synovial inflation or positive contrast radiography can be used to confirm communication of the traumatic wound with the suspected synovial cavity. Caution must be taken not to interpret wound fluid being squeezed out by synovial distension as direct communication, and this is aided by the use of contrast material. However, false negative results can be obtained, and with self-sealing punctures it may not be possible to demonstrate a direct communication.

Treatment

Antimicrobial therapy

Choice of antimicrobials should take into consideration the likely contaminating organisms, and their pattern of antimicrobial sensitivity. Enterobacteriaceae and Staphylococcus spp. are the most commonly identified isolates from equine orthopaedic patients ³,⁵. However, traumatic wounds invariably involve multiple organisms, and foot wounds frequently involve anaerobes. Based on results of sensitivity testing, and when considering both financial implications and antimicrobial prudence, a combination of penicillin G
and gentamicin represent a logical first line treatment protocol. Metronidazole should be considered additionally when managing wounds with suspected anaerobic bacterial involvement.

In cases with chronic synovial infection, or established osteomyelitis, regional intra-venous or intraosseous perfusion is an effective means of delivering antimicrobials in many multiples of the minimum inhibitory concentration (MIC). Concentrations are maintained above MIC for >24 hours, and this technique represents an effective means of overcoming in vivo antimicrobial resistance and managing difficult orthopaedic infections.

The objectives for effective treatment of synovial infection include removal of foreign material, debridement of contaminated/infected and devitalised tissue, elimination of micro-organisms, removal of destructive enzymes and radicals, promotion of tissue healing and restoration of a normal synovial environment. The endpoint of surgical treatment should be a clean contaminated status of the synovial cavity, enabling natural defences and antimicrobial therapy to eliminate remaining microorganisms. These endpoints are best achieved with synovial lavage.

Arthroscopic lavage is considered to offer several advantages over lavage with needles or cannulas, or arthrotomy, including improved visualization, identification of foreign material and infected or devitalised tissue, and access to a larger area of the synovial surfaces. Arthroscopy enables an efficiently evaluated, cleaned, debrided and decompressed cavity with minimal morbidity, reduced period of hospitalization and maximal functional recovery compared to other treatments. Following arthroscopic treatment survival rates of 90% and rates of return to previous levels of performance of 81% have been reported.

**References**