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Tutorial Article

Indications and techniques for tenoscopic surgery of the digital flexor tendon sheath

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Introduction

Tenoscopic exploration of the equine flexor digital sheath was first described by Nixon (1990) and has since provided increased knowledge regarding the pathophysiology of tenosynovitis (Nixon *et al.* 1993; Fortier *et al.* 1999; Wright and McMahon 1999; Frees *et al.* 2002). Digital flexor tenosynovitis has been described as simple, complex or septic (Honnas *et al.* 1991; Nixon *et al.* 1993; Dik *et al.* 1995). Simple tenosynovitis is characterised by distension of the digital sheath with no additional pathology involving the digital sheath or the superficial or deep digital flexor tendons (SDFT, DDFT). When not accompanied by lameness, the lay term 'windpuff' or 'windgall' is frequently used to describe the idiopathic swelling. When lameness is present, it is generally believed to be a result of digital sheath inflammation or compression of the SDFT or DDFT within the fetlock canal by the palmar/plantar annular ligament (PAL) (Adams 1974; Dik *et al.* 1995).

In cases with complex tenosynovitis, there is distension of the sheath and thickening of the PAL with additional pathology such as adhesions, synovial masses or tendonitis of the SDFT or DDFT present. While the exact aetiologies of simple and complex tenosynovitis have not been elucidated, clinically it appears that complex tenosynovitis is a manifestation of chronic, self-perpetuating simple tenosynovitis. Lameness associated with complex tenosynovitis may result from synovial inflammation, compression of the SDFT/DDFT within a stenotic fetlock canal, SDFT or DDFT tendonitis, or adhesions between tendons or between a tendon and the digital sheath. Septic tenosynovitis results from trauma, iatrogenic contamination of the tendon sheath during injection, or septicaemia. Septic inflammation and distension of the tendon sheath results in lameness. In addition to inflammation, there is frequently accompanying traumatically induced structural damage to the SDFT/DDFT.

Diagnostic evaluation of tenosynovitis

Considerable added general surgical costs, equipment and expertise are required to perform tenoscopic surgery, and it is not indicated in all cases of aseptic digital sheath tenosynovitis. Tenoscopic surgery should be considered as a first-line treatment modality in cases of septic tenosynovitis. In cases of aseptic tenosynovitis, the decision to perform tenoscopy is based on history, lameness examination and a thorough ultrasonographic examination of the digital sheath.

History

Aseptic digital sheath tenosynovitis is not always accompanied by lameness. It is imperative that a historical perspective of each case be ascertained along with thorough lameness examination and ultrasonography. Relative historical inquiries should include onset of lameness and any accompanying trauma, duration and changes in digital sheath swelling, results of previous lameness evaluations, previous medications and response to treatment. Most cases of simple tenosynovitis can be managed successfully with altered exercise regimens and intrasynovial medication. As the response to medical therapy diminishes, surgery is recommended. Once it is

Fig 1: Distention of the proximal digital sheath due to the presence of large synovial proliferative masses (arrow). Synovial masses are located typically in the proximal digital sheath and can be palpated as firm, mobile, intrasynovial structures.

decided that surgery should be performed, the results of an ultrasonographic examination will be the foundation for recommending tenoscopy or simple PAL transection.

Digital sheath synovial fluid evaluation

If there are indications in the history or physical examination to suggest that sepsis should be considered in the differential diagnosis, then synovial fluid should be obtained, evaluated and cultured. Synovial fluid evaluation in aseptic tenosynovitis is of little value and does not reflect the extent of pathology or provide prognostic value (Van Pelt 1969; Fortier *et al.* 1999).

Lameness examination

Horses with tenosynovitis are variably lame and are positive to fetlock flexion test. With careful palpation of the digital sheath, synovial masses can be detected as firm but moveable, palpable swellings within the digital sheath (**Fig 1**). The most specific diagnostic aspect of the lameness examination includes administration of anaesthetic directly into the digital sheath. There should be considerable improvement in the horse's lameness; however, it may not be abolished completely. It is of prognostic value to also administer anaesthetic into the associated metacarpo/metatarsophalangeal joint to determine whether there is concurrent joint pathology, such as osteoarthritis. The use of contrast radiography to aid in the investigation of tenosynovitis has been reported (Hago and Vaughan 1986); however, ultrasonography has replaced its usefulness. Ultrasonography should be performed by an experienced ultrasonographer using a ≥7.5 MHz probe. Ultimately, a magnetic resonance imaging (MRI) study of the digital sheath may provide the most detailed information. Currently, there are no reports of abnormal MRI studies of digital flexor tendon sheaths; however, there are comprehensive data describing normal MRI images of the equine distal limb (Denoix 2000).

Ultrasonographic examination

There are several thorough descriptions of ultrasonographic technique and normal anatomy of the equine digital sheath (Dik *et al.* 1991, 1994, 1995). It is important to perform examinations in transverse, longitudinal and oblique planes of the entire length (14–20 cm) of digital sheath from its origin at the bifurcation of the suspensory ligament to the proximal extremity of the middle phalanx.

On ultrasonography, there are 2 areas where adhesions are commonly misdiagnosed (Dik *et al.* 1995). The first is the mesotenon in the proximal aspect of the digital sheath that connects the DDFT to the sheath wall both medially and laterally. This mesotenon is noted in transverse ultrasonographic images as echogenic bands. The second area is the normal midline adherence of the palmar aspect of the SDFT to the sheath wall in the area of the fetlock and proximal pastern. Having noted that there are areas where normal anatomy may be mistaken for pathology, it is increasingly clear that ultrasonography is not a sensitive diagnostic tool when investigating the extent of damage to the DDFT or SDFT in the area of the *manica flexoria* where the SDFT forms a ring around the DDFT (Barr *et al.* 1995; Wright and McMahon 1999). While most lesions in this area can be detected, **ultrasonography typically underestimates the extent of tendinous damage**, particularly with respect to longitudinal tears or fraying of the DDFT or tears of the *manica flexoria* (**Figs 2a–d**).

During ultrasonographic examination, it is common to measure the dorsopalmar/plantar thickness of the PAL, with normal considered to be <2 mm (Dik *et al.* 1991). However, in chronic cases of tenosynovitis, it may be difficult to distinguish the PAL from subcutaneous tissue and attempts at measurement frequently contain both. When focusing on the tendons within the fetlock canal and attempting to determine whether there is flattening of the SDFT or DDFT, **it should be remembered that there are large variations in dorsopalmar/plantar measurements depending on the breed and age of the horse being examined** (Dik *et al.* 1991; Verschooten and De Moor 1978). However, the ratio of SDFT:DDFT measurement is fairly constant at 0.4–0.6. There are no studies directly correlating the degree of SDFT/DDFT flattening with prognosis; however, flattening is most frequently seen in very chronic cases and is presumed to be a result of chronic compression within a stenotic fetlock canal.

Indications

Following characterisation of the tendon sheath pathology, the decision to perform tenoscopic exploration is relatively straightforward. **Tenoscopic surgery is of value for any of the indications described below.**

Tenosynovitis refractory to conservative medical management with no specific ultrasonographic findings

Diagnostic tenoscopy in cases where there are no clear ultrasonographic abnormalities of the digital sheath provides a more accurate diagnosis of the aetiology of each case, and expands the basic knowledge of digital sheath tenosynovitis aetiologies and pathology. Subsequent to exploration of the digital sheath, a more case-specific, tailored treatment may be applied.

Tenosynovitis with ultrasonographic abnormalities

Synovial proliferative masses

Large synovial masses are typically located in the proximal sheath. Histologically, masses are composed of proliferative fibrous tissue with abundant fibrovascular stroma; haemosiderophages may be present. The histological diagnosis is typically chronic, proliferative, villonodular

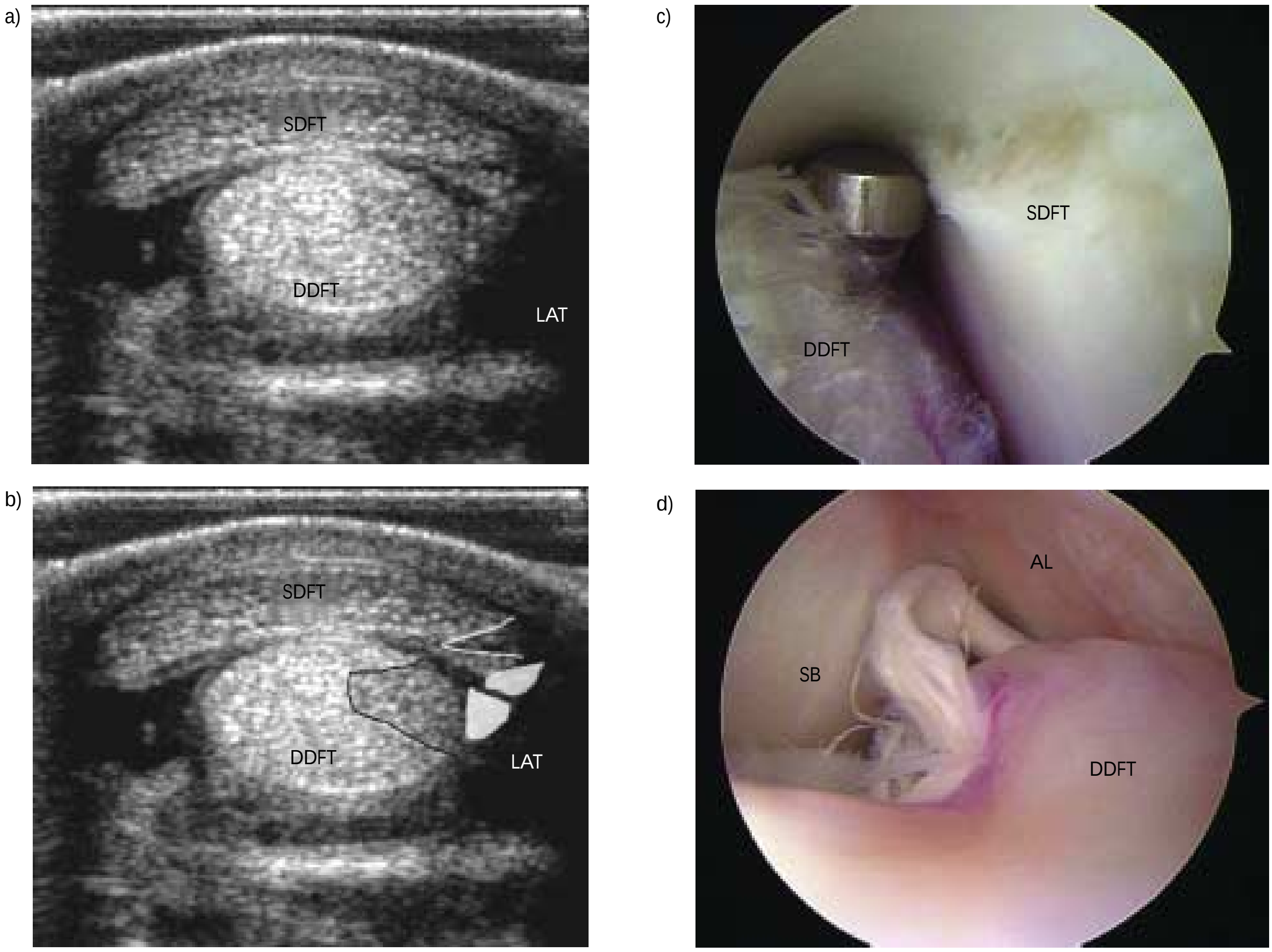

***Fig 2:** a) Transverse, midline ultrasonographic image approximately 18 cm distal to the base of the accessory carpal bone; note the lack of definition in the lateral edge of the superficial digital flexor tendon (SDFT), the presence of echogenic tissue lateral (LAT) to the deep digital flexor tendon (DDFT) and decreased echogenicity in the lateral third of the DDFT. b) The same image as (a) with the noted pathology highlighted. c) The areas outlined in both the SDFT and DDFT were found at tenoscopy to represent longitudinal tears in the SDFT and DDFT. d) The solid white areas lateral to the tendons, depicted in (a) and (b), corresponded to frayed tendon edges. AL = Annular ligament; SB = sesamoid bone.*

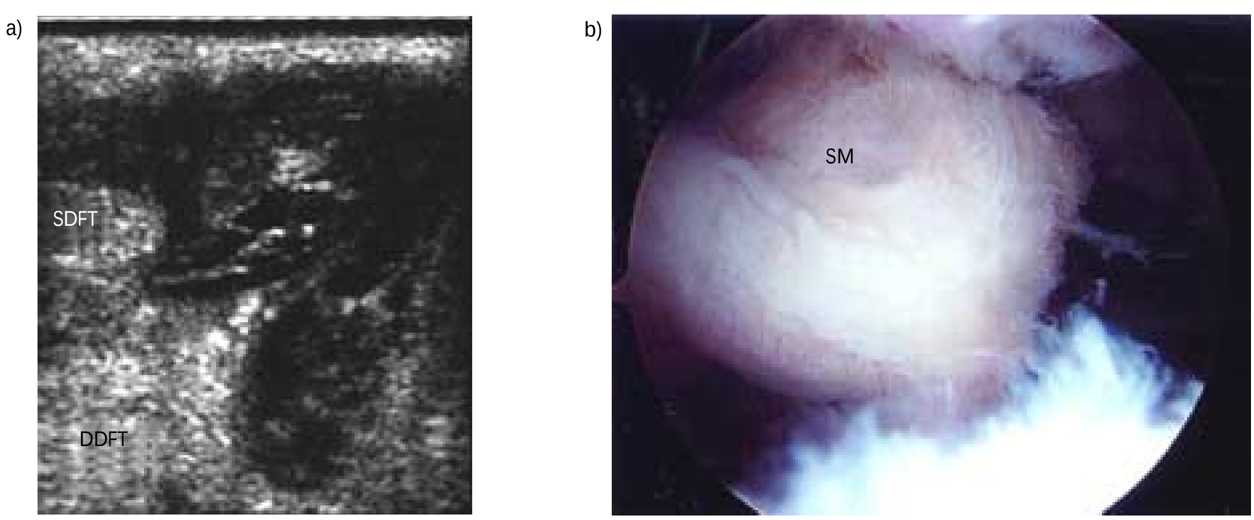

***Fig 3:** a) Transverse ultrasonographic image of the proximal, palmarolateral digital sheath. Note the presence of echogenic tissue occupying the majority of the digital sheath. It is not apparent whether the tissue (masses) originates from the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT) or the digital sheath. b) An intraoperative image of the synovial mass (SM).*

Fig 4: External appearance of the distal limb of a horse with distal superficial digital flexor tendonitis and accompanying distension of the digital sheath. Swelling of the tendon confers the appearance of palmar annular ligament constriction.

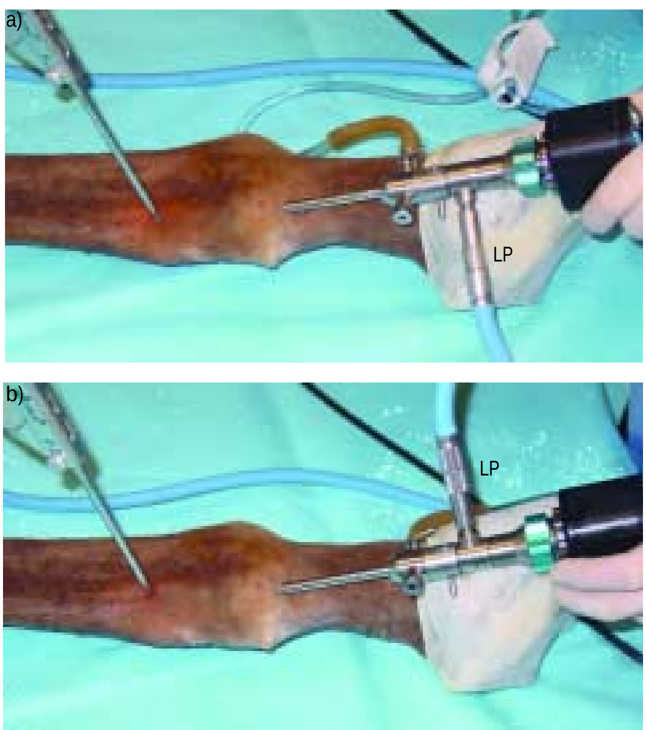

Fig 5: a) Positioning of a standard arthroscope (opposite-side light post/direction of view) for viewing the uppermost aspect of the digital sheath. Note the interference between the light post (LP) and the foot of the horse. b) Demonstrating the utility of a same-side LP/direction of view arthroscope when performing tenoscopy. Interference between the LP and foot are minimised, resulting in improved mobility within the digital sheath and increased ease of operation.

Fig 6: Free-hand transection of the palmar annular ligament using a bistoury under tenoscopic guidance.

Fig 7: Intraoperative image of tenoscopic guidance of bistoury, free-hand transection of the palmar annular ligament (PAL). It is imperative that the chosen cutting instrument be passed outside the **manica flexoria** *(MF) to avoid inadvertently damaging it during PAL transection.*

synovitis. There are no histological indices suggesting that the masses are neoplastic. Most masses originate from the tendon sheath, but they may also arise from either tendon (**Figs 3a,b**). Synovial masses are thought to be a manifestation of chronic tenosynovitis and in rare instances may be present without associated lameness. Synovial masses are pathological in that they are space-occupying lesions which interfere with the mechanics of the tendon sheath, and movement of the masses within the tendon sheath incite a painful response originating from tension at their base on the digital sheath or tendon.

Adhesions

Adhesions between the sheath and either the SDFT or DDFT or between the SDF/DDF tendons are always painful and adhesiolysis is required for return to soundness. Complete removal of the adhesion is recommended over simple transection in order to prevent reformation of adhesions in the post operative phase.

Distal bows

Focal tendon fibre disruption of the DDFT/SDFT in the distal metacarpal/metatarsal region (low bows) may be present in tenosynovitis (Barr *et al.* 1995; Dik *et al.* 1995; Fortier *et al.* 1999) (**Fig 4**). Tendonitis of the DDFT is particularly slow to heal and historically carries a guarded prognosis for return to athletic function when treated conservatively or by PAL transection through an open approach (Barr *et al.* 1995; Dik *et al.* 1995). In one study (Barr *et al.* 1995), 8 horses with distal DDFT tendonitis were treated with an open approach for PAL desmotomy. Of those 8 horses, 3 also had adhesions removed and 2 developed post operative infection. Two out of the 8 horses resumed athletic activities, which was comparable to the 5/16 horses treated conservatively. There are no reports on a population large enough for analysis; however, tenoscopic exploration and PAL desmotomy would be likely to improve these results by allowing more complete exploration of the digital sheath for adhesion removal and decreasing post operative infection rates. More recently, longitudinal tears in the DDFT were described and addressed through tenoscopy (Wright and McMahon 1999). As noted above, ultrasonography is not an accurate tool for detecting the extent of longitudinal tendon tears or lesions associated with the *manica flexoria*. Tenoscopy in these circumstances allows a more accurate diagnosis and the surgeon gains access to debride free tendinous tissue. With increased accuracy of diagnosis, more specific treatments and prognostic indices will ensue.

Septic tenosynovitis

The use of tenoscopy for treatment of septic tenosynovitis has replaced needle lavage and there is increasing support for its use in the primary treatment of septic tenosynovitis (Gaughan 1994; Baxter 1996; Frees *et al.* 2002). In septic tenosynovitis, tenoscopy provides value through effective lavage, evaluation and debridement of tendinous lesions, and evacuation of fibrin and debris. In severe cases, PAL transection should be considered in an attempt to increase circulation, improve the comfort level of the horse and diminish the potential for contralateral limb laminitis. Insufficient reports are available to critically assess combined tenoscopy and PAL transection in the management of septic tenosynovitis. However, clinically, it appears to increase survival percentages (Honnas *et al.* 1991; Gaughan 1994).

Palmar/plantar annular ligament transection

Transection of a thickened PAL *per se* is not an indication for tenoscopic surgery. When thickening of the PAL is the sole pathology present and there are no indications on ultrasonographic examination of additional lesions involving the tendons or the tendon sheath, then simple PAL transection without tenoscopy is appropriate and may be performed in the standing horse (McIlwraith 1987). However, in most instances if tenoscopy is indicated then so is PAL transection, and it should be remembered that **most cases of longitudinal tearing of the DDFT are not accompanied by thickening of the PAL or clear ultrasonographic abnormalities and are diagnosed only through tenoscopy** (Wright and McMahon 1999). When additional tendon sheath structures are involved and tenoscopic surgery is performed, then the PAL is transected under tenoscopic guidance. Direct visualisation of the PAL during transection allows the operator to be anatomically precise in the location and extent of the transection, thereby avoiding structures such as the *manica flexoria* while ensuring complete division of the ligament.

Advantages of tenoscopic surgery

The advantages of tenoscopic surgery include **complete examination of the tendon sheath, increased accuracy in diagnosis, complete removal of synovial proliferative masses and adhesions, accurate transection of the PAL** and **decreased surgical wound size** (Nixon *et al.* 1993; Barr *et al.* 1995; Hawkins and Moulton 2002). It is often disputed as to whether tenoscopy is necessary, since all of these manoeuvres can be performed through an open approach. While it may be possible to adequately address some sheath pathology through an open approach, tenoscopy offers the advantages of more extensive visualisation, greater diagnostic value and decreased surgical wound size (Dik *et al.* 1995; Wright and McMahon 1999). Since the advent of tenoscopy, there have been fewer reported cases of post operative synovial fistulation and infection compared with reports using an open approach (Gerring and Webbon 1984; Wright and McMahon 1999). Additional advantages of reduced wound size include shortened hospitalisation periods and a rapid return to walking as a substitute for passive motion, which has been shown to increase tendon healing and preserve the necessary gliding function of an ensheathed tendon (Takai *et al.* 1991; Zhao *et al.* 2002).

Surgical equipment and procedures

Patient preparation

If tenoscopy is to be performed in a hindlimb, then epidural analgesia should be considered to aid patient comfort during surgery and in the post operative phase (Goodrich *et al.* 2002). Intrathecal anaesthesia may be used if a forelimb is operated on or if no epidural was performed prior to hindlimb tenoscopy. Antibiotics, such as procaine penicillin (22 mg/kg bwt i.m., b.i.d.), and a nonsteroidal anti-inflammatory drug, such as naproxen sodium (10 mg/kg *per os* b.i.d.) or phenylbutazone (4.4 mg/kg bwt *per os* b.i.d.) are administered preoperatively and continued for 48–72 h post operatively. The horse is positioned in lateral recumbency with the affected limb placed uppermost. If there is a disparity in the extent of pathology between the medial and lateral aspects of the digital sheath, then the side of the sheath with the greatest pathology is placed uppermost. An Esmarch bandage and tourniquet are necessary to maintain visualisation during mass or adhesion removal and during transection of the PAL. According to surgeon preference, the tourniquet may be applied just proximal or distal to the carpus or tarsus.

Surgical technique

The entry portal for routine tenoscopy of the digital sheath is on the palmarolateral surface, just distal to the annular ligament and palmar to the palmar neurovascular bundle (Nixon 1990). Tenoscopy can be performed using a standard 4 mm 25° opposite-side light post/direction of view (forward viewing) arthroscope (**Fig 5a**). If available, a 30° same-side light post/direction of view (reverse viewing) arthroscope[1] is beneficial to minimise interference between the light cable and foot (**Fig 5b**). The digital sheath is explored and hypodermic needles are used to ascertain an appropriate site for ipsilateral instrument entry in the proximal sheath. Typically, masses, adhesions and additional pathology are addressed prior to PAL transection. However, if severe PAL constriction limits movement of the arthroscope within the fetlock canal, then transection is performed at the beginning of surgery to increase manoeuvrability within the sheath. This strategy should be reserved for the rare case, since haemorrhage from the transected annular ligament may interfere with visibility.

Removal of synovial masses and adhesions

Synovial masses and adhesions are most efficiently removed with the aid of a motorised synovial resector[1]. Alternative methods include use of an arthroscopic biopsy cutting forceps[1], or a retractable blade and grasping forceps. In the majority of cases, all therapeutic manoeuvres can be performed from the same instrument portal; however, if necessary, a second instrument portal on the 'down' side of the tendon sheath can be created.

Addressing tendon injuries

Typical 'low bows' of either the SDFT or DDFT with no other tendon sheath pathology do not need to be addressed tenoscopically. Simple PAL transection through a closed approach is adequate to relieve compression of the flexor tendon within the fetlock canal. In these situations, tenoscopy may still provide the advantage of direct visualisation for accurate application of additional methods of tendon healing such as intralesional injections of insulin-like growth factor-I (Dahlgren *et al.* 2002) or bone marrow elements (Smith *et al.* 2003). Longitudinal tears of the DDFT should be addressed through tenoscopy; they may be undetected by ultrasonography or may appear as focal, irregular, anechoic areas in the margins of the DDFT and may be accompanied by echogenic material within the sheath adjacent to the digital flexor tendons (Barr *et al.* 1995; Wright and McMahon 1999). Lesions associated with the *manica flexoria* can occur as longitudinal tears (Wright and McMahon 1999) or as fraying of the proximal border. For both longitudinal tears of the DDFT and for tearing of the *manica flexoria*, simple debridement of loose edges is recommended. An open approach with subsequent suturing of DDFT longitudinal tears has been performed in the past, but is no longer advocated (I.M. Wright, personal communication). The merit of currently available methods for arthroscopic suturing[2] has not been evaluated.

Palmar/plantar annular ligament transection

The original method for tenoscopic PAL transection employed a slotted cannula and a 90° knife set[1] (Nixon *et al.* 1993). The advantages of using a slotted cannula include precise control and direct visualisation during PAL transection. Other methods of PAL transection have been described using different slotted cannula sets (Hawkins and Moulton 2002), free-hand transection with a meniscal knife (J.P. Walmsley, personal communication) or free-hand transection with a bistoury (**Fig 6**). Regardless of the method chosen, the important surgical details include ensuring through direct tenoscopic visualisation that the chosen cutting instrument is outside the *manica flexoria* (**Fig 7**) and that the PAL is completely transected in both depth and length.

Aftercare

Sodium hyaluronate (40 mg) is injected into the digital sheath subsequent to skin closure to aid tendon repair and prevent adhesion formation (Amiel *et al.* 1989; Gaughan *et al.* 1991). The capacity of sodium hyaluronate to sterically hinder inflammatory mediators and function as a viscoelastic fluid is related to its molecular weight (Howard and McIlwraith 1993). It is therefore recommended that high molecular weight ($>2.0 \times 10^6$ Da) sodium hyaluronate preparations (e.g. Hylartin V)[3] be administered. A second injection at the time of suture removal (10–14 days post operatively) is recommended. A firm, sterile bandage should be maintained for at least 10 days post operatively to protect the skin incisions and minimise swelling. Hand-walking should begin within 1–2 days after surgery in an effort to prevent adhesion formation. In horses that are severely lame, use of a heel extension or heel wedge shoe may increase the post operative comfort and allow increased exercise. Return to work is based on the degree of tendinous damage and the result of repeat ultrasonographic examinations.

Summary

The prognosis for horses affected with complex tenosynovitis addressed through tenoscopy appears to be fair to good with approximately 70% (Fortier *et al.* 1999) to 80% (J.P. Walmsley, personal communication) of horses returning to athletic performance. The prognosis decreases for horses with longitudinal tearing of the DDFT, with only 54% of horses returning to work (Wright and McMahon 1999). There are no large reports of horses with low DDFT bows treated with tenoscopy or simple PAL transection; however, studies suggest that PAL transection is beneficial (Barr *et al.* 1995; Dik *et al.* 1995). Tenoscopic surgery with PAL transection should be performed in those horses afflicted with tenosynovitis when synovial proliferative masses, adhesions or suspicious ultrasonographic findings are noted, or when no ultrasonographic abnormalities are identified but the tenosynovitis remains refractory to conservative management. In cases of simple PAL desmitis or tendonitis of the distal DDFT/SDFT, routine PAL transection without tenoscopic guidance may be sufficient.

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Manufacturers' addresses

[1]Dyonics, Smith and Nephew Endoscopy Inc, Andover, Massachusetts, USA.
[2]Arthrex, Naples, Florida, USA.
[3]Pharmacia Animal Health/Pfizer Inc., New York, USA.

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