Beni-Suef University
Faculty of Veterinary Medicine
Surgery, Anesthesiology, and Radiology Department

ABSCESS

Definition: -

It is a circumscribed swelling containing pus that is formed by pyogenic micro-organisms by destruction of tissue.

Predilection seats: -

Abscesses can be formed at any part of the body of the animals.

Equines, sheep and goats…….. parotid region and inter-mandibular space

Cattle…… left chest region behind elbow joint, in front of the udder and at the umbilicus

Etiology: -

Entrance of microorganisms through a break down in the skin or mucous membrane

1-Presence of foreign body as nail, needle, sharp piece of bone, wooden, or glass .... etc.

2-Injuries or accidents and skin wounds

3-Wide bore needle which drives a piece of skin or hair into the muscle and improper sterile technique for injection.

Classification: -

Abscesses are classified according to the clinical features into

a-Acute or hot abscess of rapid evolution, and it may be superficial or deep

b-Chronic or cold abscess of slow evolution and it may be hard or soft

Each of the above types may be distinguished as

a-Idiopathic

b-Symptomatic

c-Metastatic when there are multiple foci

d-Critical when it resulted from grave disease or develops in connection with vital organ

I-Acute or hot abscess: -

Formation and structure of an abscess: -

-An acute abscess is formed within 3-5 days after entrance of the pyogenic micro-organism

-It is composed of wall (pyogenic membrane) and contents (pus), and the character of the pus varies according to tissue involved and causative agent

-The bacteria that have gained access to the tissues multiply and produce toxins that diffuse into surrounding structures leading to acute inflammation, vasodilatation, accelerated blood stream, and finally retardation of blood stream, thrombosis and leucocytic emigration

-Microscopically, the lesion shows two well differentiated zones

a-Central area of dead tissues that have lost their staining properties and contain the causative pyogenic bacteria

b-Peripheral zone of acute inflammation which is highly infiltrated with leucocytes and fades gradually into the surrounding healthy tissues

Fate of pus: -

-Usually the pus directed to the external surface of body, but if it is unable to escape superficially owing to tissue resistance, as horn of the hoof, it extends in the direction of the least resistance until it finds a means of escape.

-An abscess in vicinity of joint or visceral cavity may open into it with leading to serious consequences.

- Abscess formation on ligament, tendon, or bone may cause necrosis of these structures, that interferes with healing even after the abscess burst

-Retained pus in an abscess cavity for a long time without evacuation causes resorption of liquid part of the abscess, inspissation, caseation, and finally calcification.

I-Symptoms of an acute superficial abscess: -

-The signs are the general signs of acute inflammation (swelling, redness, hotness and pain), and it starts as a very painful circumscribed inflammatory swelling which is firm on manipulation.

-The center of the swelling gradually becomes softer while its periphery remains firm, and gradually the wall becomes thin and the abscess appears to be fluctuated.

-Later on it points at the skin surface, forming a shining hairless patch at its center which is thin on palpation giving a sensation of softening combined with elasticity.

-At the end it burst allowing escape of pus through the orifice.

II-Symptoms of an acute deep abscess: -

-As a result of the deep position of that abscess, local manifestations can't be noticed except slight edema in its vicinity, and it is first indicated by febrile condition of the animal due to absorption of toxins.

-It may interfere with normal function of surrounding organs like pharynx or larynx

-When the pus reaches near the surface, features of a superficial abscess may be detected

Diagnosis: -

Diagnosis of superficial abscess is always easy by symptoms while deep one may present some difficulties as a result of absence of local manifestation. Generally, edema at the vicinity, interference with normal function of surrounding organs and febrile condition may be helpful.

1-History 2-Clinical signs 3-Exploratory puncturing

Differential diagnosis: -

Abscess may be confused with hematoma, cyst, hernia, bursitis or tumor.

1-Hematoma: -

a-It appears directly after severe trauma, and immediately fluctuating beneath intact skin

b-Transient inflammatory reactions can be seen for few days then disappear, but generally pain is not as severe as in abscess.

c-Crepitation ensues when coagulation occurs

d-It never points as the abscess

2-Cyst: -

a-It is a uniformly fluctuating cavity in a tissue, lined with epithelium or endothelium.

b-It is either congenital or it takes longer time to develop

3-Hernia: -

a-Presence of hernial ring, and reducibility of contents in case of reducible hernias

b-Absence of inflammatory reaction except when it is recent and traumatic

4-Tumor: -

a-It is abnormal benign or malignant overgrowth of tissue

b-Benign tumors are firm in palpation, grow slowly, either single or multiple, and remains localized with regular and well-defined borders without any sign of inflammation. In some cases it may be subjected to friction leading to ulceration and infection.

5-Bursitis: -

-The inflammatory swelling of these bursae is known from their anatomical position.

Treatment: -

1-Conservative: -

Conservative treatment of an abscess includes

a-Systemic antibiotic for control of septicemia and bacteremia and it should be continued even after evacuation of abscess

b-Anti pyretic or anti-inflammatory according to need

c-Fluid therapy if the animal refuses to eat as a result of toxemia

2-Ripening: -

-It is a process aims at faster maturation of the abscess to come close to the skin surface, become fluctuating and the pus lies within a thin wall cavity beneath a thin circle of skin, and inflammation of the surrounding tissues subsides.

-This can be done by using

1-Fomentation and/or poultices

2-Antiphlogestic preparations such as ichtyol ointment
3-Iodine ointment
4-Blister like bin-iodide of mercury ointment

3-Evacuation and drainage: -

-It is a process of incising the mature abscess for evacuation of pus and drainage
-The incision must be wide enough to prevent re-accumulation and placed at a suitable site for good drainage

Technique: -

1-The area should be shaved, washed with soap and water, dried, and suitable antiseptic like Tr. Iodine should be applied.
2-Sterilized abscess knife or scalpel is used to open the abscess from its point and downward so that drainage occurs by gravity when the animal stands in normal position
3-After evacuating the pus, the cavity should be irrigated with antiseptic solution, to promote the complete evacuation and removal of the contents
4-The abscess cavity should be thoroughly examined for the presence of foreign body.
4- if the abscess is not pointing at a dependant protion it is sometimes necessary to make another opening in the dependant portion to provide drainage. this is called a "counter-opening". in order to make a counter-opening, an artery forceps may be
a) burst opening of an abscess.
b) presence of a gape in the abscess cavity.
c) formation of a counter opening.
5- after opening the abscess and irrigation of ————— ,t -tuffe • with gau* dipped in tr. iodine. this is tended to destroy y
infection remaining there in and also to exert a rmld
action to stimulate the healing process.
6- the gau* packs are removed after 24 hour. ^

and then the abscess cavity is irngated with a m ^ lotion. the conventional method was to .mgate wuha ^ solution of acriflavin sulphate as it is a soluuon wruch r ^ antiseptic properties even in the presence of pus.
permanganate, dettol, savlon, iodine bovidine, hao2 or another^ antiseptic solution can be used for irrigation.
7- topical application of antibiotics or sulphonamides in the form of ointments or dusting powder is indicated if virulent infection is suspected, and systemic use of antibiotics may also be necessary in some cases.
8- daily dressing of the abscess cavity and changing the drain (seton) till the healthy granulations are seen filling its gap. the normal time required for the complete healing of an opened out abscess is usually about three weeks.
n.b.: it is not ordinarily advisable to open an abscess which is not fully ripe as secondary abscess, may form afterwards. however abscesses situated close to a joint or peritoneum may have to be opened before fully mature to avoid the chance of rupture into the joint or peritoneal cavity.
deep abscesses: r
in dealing with deep abscesses near to a serious area with great blood vessels, nerves or vital organs such as parotid region or subpharyngeal region (critical abscesses), the following steps may be employed:
1- incision of the skin without deeply puncture.
2- pushing a blunt instrument (artey forceps or blunt scissors) through the underlying tissues to reach the abscess cavity. open the jaws of the instrument without sharp cutting.
3- drain the content, then irrigate the cavity with mild antiseptic.
4- explore the cavity with sterile gloved finger to ascertain a foreign body or necrotic tissues. " "t,.
5- inserte a drain dipped in tr. iodine and daily dressing; 1s advisable.

in mucous cavity:

an abscess in mucons cavity like pharynx, rectum or vagina may be opened by one of the following:

1 . thrusting the finger into its thin wall.

2 by using a concealed knife.

3 by means of a trocar and canula.

4 by an ordinary pointed scalpel guarded or enveloped in gauze or cotton wool just up to its point to serve as a guard and control the use of the instrument.

n.b.: the persistent discharge from an opened out abscess usually indicates inadequate drainage due to either small orifice or retention of dead tissue e.g. sequesterum or foreign body. also, it is may be due to persistence of suppuration as a result of secondary infection or ineffective antiseptics used.

b- chronic or cold abscess

these abscesses grow very slowly and show very slight inflammatory reactions, therefore pain in these cases is either very slight or absent.

etiology:

1- repeated simple wounds as those induced by the saddle. wounds of the long prominces as the ribs or the pelvic bones. there are two types of these abscesses:

a^ £old soft abscess: where the abscess contains a large amount of pus and its surface is soft.

' £oid—hard abscesses: in which case the abscess is surrounded by fibrous tissues and the pus contents are small in quantity.

and as a

symptoms:

1- absence of inflammatory symptoms or the presence-$$f mild inflammation.

2- the abscess appears as a fibroma in cold harc_

cyst in cold soft one. ^ diagnosis:

exploratory punctures. ' treatment:

the same as in hot abscesses by maturation and evacuation. blister may be applied to render the abscess acute and bring the pus near to the surface before opening it.

in some cases where pus is inspessiated curetting of the abscess cavity is necessary then application of a drain immersed in tincture iodine. a counter opening for drainage may be essential in some cases.
incapsulateff abscess can be excised surgically within its intact capsule. then the skin wound was sutured.
2- acne "furuncle"
acne, furuncle or boil is an abscess involving the sebaceous
gland.
the disease occurs in all domestic animals but is common in
the horse and dog. in the dog it is more common in short haired breeds. the region rich in sebaceous glands (like nose, lips ... etc) are often affected.
etiology: :
the infection is caused by staphylococci. local irritation from any cause (e.g. friction of saddle or collar) predisposes to the infection.
symptoms:
the lesion may appears as single pustule or as a group of pustules. the pustule may has the size of a pea. when it ruptures grayish white pus is given out. a grayish white core of necrotic tissue comes out when the pustule is compressed between fingers.
.-a
treatment: . ..« *"
wash thoroughly with soap and warm water. apply an antiseptic and salicylic acid ointment ... etc. some of the pustules may require to be incised to remove the necrotic core. they are after wards touched with tr. iodine. topical and systemic antibiotics is very effective.
3- phlegmone
a phlegmone is a diffuse inflammatory swelling which fades gradually into the surrounding structures without any definite demarcation. it may be:
1- septic:

caused either by bacterial invasion or by infiltration of the tissues by one of the body excretions as urine or faeces.

2- aseptic:

caused by infiltraion of the subcutaneous tissues by an irritant material as terpentine oil, chloral hydrate or concentrated saline solution.

causes:

1- trauma followed by infection of microorganisms.

2- infiltration of the tissues by body excretions or an irritant material.

3- secondary to local suppurative lesion as abscess, lymphadenitis or arthritis.

symptoms:

1- presence of local diffuse swelling which fades gradually in the surrounding structures.

2- local tenderness and hotness.

3- the lymphatic glands draining the area are usually inflamed.

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4- the body temperature rises and sharply fluctuates.

treatment:

put the affected part in complete rest then apply: 1- hot antiseptic fomentation with compression antiphlogestic poultices and bandage if practicable.

or

apply

o- if the phlegmone is so voluminous and threatens the >r cu! iti in the area, incise it several times (scarification) to provide i drainage then dress it as septic wound.

3. systemic sulphonamides or antibiotics are essential and if the- • is a wound or incision, antititanic serum should be given.

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4- fistula and sinus

a fistula is an abnormal tract joining between two cavities as the recto-vaginal fistula or between a cavity and the outer surface as fistulous withers or between a canal and the exterior as milk and salivary fistulae. ,,,

if the end of the tract is clos|ii (has one opening], it is called a sinus.

fistulae are classified into:-

1- heriditary (congenital) fistula: <"<•

as an example the uracus where the umbilical cord is closed except the uracus where the urine is found to come out from it as well as from the natural orifices in the penis in rhales:and in the vagina in females.

2- pathological (acquired) fistula:

it is a fistula resulting from a pathological condition as a dental fistula, caused by a diseased tooth or quittor caused by necrosis of the lateral cartilage of the hoof.

jf" fistula may be also classified into:

1- purulent fistula: a fistula discharging pus.

2- specific fistula: a fistula caused by a specific infection as actinomycotic fistula and botryomycotic fistula.

3- non-purylent fistula: a fistula discharging any secretion rather than pus. these non-purulent fistulae are subdivided into:

a) excretory fistula: as the intestinal fistula, anal and urethral fistula. ^

b) secretory fistula: as milk and salivary fistulae. ,.'

etiology:

1- the presence of a foreign body or any necrotic tissue at the depth of the fistula. specific affections as actinomycosis and carcinomas. 3- abscesses of the parotid region and parotid duct may open to

the inside destroying the gland or duct resulting in a fistula. 4. opening an abscess in a wrong way as from its upper part or

insufficiently draining it may result in tb'; formation of a fistula

or sinus.

symptoms:

the presence of a small opening discharging pus of bad odour or discharging non-purulent exudates. this depends upon the type of fistula. a probe can be introduced from the opening to detect the depth of the fistula and whether there are sid canals or not. the fistula opening is surrounded by an unhealthy granulation tissue. in many cases more than one opening may be present. several scars around the fistula opening is an indication that the fistula is old. some inflammatory reactions may accompany the fistula.

a purulent fistula is composed of an opening, a canal and a
depth.)

';t» 1- fistulous opening: ..*-?" ^

a purulent fistulous opening is usually small in size denuded from hair. the skin around the opening epithelialize gradually until the opening is closed by a scar, but sooner or later pus accumulates in the depth forming a new abscess which bursts by a new opening beside the old one. 2~ t/ie jlstulous canal:

it is a canal joining the fistulous opening with the depth. it may be straight and short as in cases of quittor or picked-up nail or be long and tortuous as in cases of fistulous withers and fistulae.

therefore it is preferable to use an "s" shaped probe in cases
!stulae of long canals and a staight probe in cases of short fistiuae

3- the depth:

it contains usually the real cause of the fistula which may be a foreign body, as a nail, suture material, piece of gauze, a necrotic tendon or a necrotic piece of bone. „ -*

treatment:

in fistulae with short canals, it is enough to curette the canal and its depth but when it is impossible, an incision is made including the whole tract, then irrigate the wound with antiseptic solution and the foreign body is extracted from the depth if present.

in fistulae with long canals the following steps are undertaken: 1 - drainage should be enough by performing a counter opening.

2- liquid or solid caustics can be used. they help in the separation of necrotic tissues (silver nitrate or copper sulphate).

3- the use of hot iron in the form of a rod heated till it becomes red and is introduced inside the fistual tract to be directly withdrawn. this method helps in tlie separation of necrotic tissues.

4- surgical opening of the fistula through the whole length till its depth. necrotic parts and foreign bodies should be removed by a curette.

in some cases where we cannot reach the depth of the fistula surgically, it is enough to perform curetting and washing with antiseptics.

5- in some cases of secretary fistulae, a purse string suture may be used after freshing the lips.,

6- in secretoty fistula with a small orifice some 'drugs which have the power to enhance connective tissue formation may be useful-in these cases injection of 0.1 cc. is given at 6 places around the orifice, subcutaneously and another 2 injections 0.1 cc, also inside the fistula orifice under the mucocus membrane.

cases of secretory fistula which do not respond to one of
the previous treatments as parotid fistula must be treated by
reventing salivary secretion. this is done by injecting tincture
iodine or paraffin heated up to 40°c inside the parotid duct 3-4
times.

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AFFECTIONS OF BLOOD VESSELS

I-Affections of arteries: -

1-Contusions: -

Non-significant as a result of elasticity of artery. When an artery is severed by contusion, the inner and middle coats contract and retract within the outer coat, and this promotes thrombus formation.

2-Open wounds: -

Arterial wounds may be penetrating or non-penetrating. Non-penetrating wounds cause a weak point in the vessels wall predisposing to aneurism. The wound may be punctured, incised, contused, or lacerated.

Punctured wound may be caused by sharp pointed objects, a piece of bone during fracture, or during surgery (neurectomy or phlebotomy) and gravity of the wound depends up on

1-the nature of the inciting object. 2-the size of the puncture. 3-the location of the artery.

Incised wound may partially or completely sever the artery and severing of large vessel may cause fatal hemorrhage, while those with smaller caliber, deeply situated, and associated with narrow wound in the overlaying tissue, may be followed by natural hemostasis with thrombus formation that is organized 40 days later. Before organization of the thrombus, hemorrhage may recur if the wound is subjected to violence or the blood pressure increased. Partial section of the vessel may be oblique, transverse or longitudinal. If the oblique or transverse sections are small, spontaneous hemostasis may occur as in case of punctured wound. If more than half the circumference of the vessel is involved, the wound retracts due to the elasticity of the wall and the constant force of the blood stream prevents the formation of thrombus. On the other hand, longitudinal wounds are less gaping, and so it is not so dangerous.

When an artery is torn, the inner layers recoil and covered by the outer layer that promotes coagulation, and this is the main idea of hemostasis by torsion or ecraseur.

Characteristics Of Arterial Hemorrhage:

1-The blood escapes in jets that coordinate with the ventricular contraction, but if the artery is so deep, the pulsatile movement may be not clear.

2-The blood is bright red.

3-The bleeding is dimensioned or arrested by pressing the cardiac side of the wound, and when bleeding continues, it may be due to anastomosis with another artery at the distal portion.

Varieties Of Hemorrhage:

1-Primary or immediate hemorrhage 2-Recurrent or intermediary or reactionary hemorrhage

3-Secondary hemorrhage

Prognosis Of Arterial Wounds:

Prognosis depends up on the size of the wound, the species of the animal (hemostasis occurs faster in dog, ox, sheep, and horse respectively), and the nature of the injury (complete severing is better than partial severing of the artery, as the inner wall retract in the former controversial to the later).

3-Ulceration of artery: -

The wall of an artery can be subjected to ulceration by the pyogenic microorganisms as with abscess formation and fatal bleeding can occur depending up on the caliber of the vessel.

4-Rupture of artery: -

Artery may rupture as a result of laceration by fractured bone or violent effort as struggling or jumping.

Symptoms:

When a superficial artery ruptures, subcutaneous pulsating hematoma beneath the skin ensues (diffuse aneurism), but when a large internal artery ruptured, death may occur within few hours.

Treatment:

Small superficial ruptures treated as hematoma, while internal ruptures are out of treatment.

5-Aneurism: -

Aneurism is seen frequently in horses as a result of strongylus vulgaris. External aneurism is distinguished as a pulsating swelling on the course of an artery, it expand at each pulsation. The main complication of an aneurism is rupturing with fatal hemorrhage.

Treatment:

Ligation of the artery above and below the aneurism and extirpation of the aneurism after ligation.

6-Arteritis and arterial thrombus: -

Arteritis always precedes thrombosis. It is caused by irritation of the endothelium by bacteria or parasite, or over stretching of the endothelium. The rough surface of the artery permits thrombus formation that starts small and later on increase in size and extends to the first collateral branch and causes complete occlusion. Partial thrombus affect the need of the tissue to blood, even if the animal doesn't suffer any clinical signs, but when the animal is active, the blood supply becomes relatively insufficient.

Symptoms of aortic and ileac thrombosis:

The symptoms of thrombosis at bifurcation of the aorta are characteristic, the horse is quite normal at rest, but after exercise, he stops and shows symptoms of distress and even the animal may lying down. If the case is unilateral, the affected limb may be cold and has no prominent veins like the health leg. On rectal examination, the location of the thrombus can be detected. The prognosis is grave because the case is usually incurable.

Treatment:

There is no satisfactory treatment of the condition, and the following measures are tried without definite success.

1-Adminstration of potassium iodide, or heparin.

2-Massage of the aorta per rectum (fragmentation of the thrombus may cause embolism and death of the animal).

3-Rest followed by gradual exercise.

II-Affections of veins: -

1-Open Wounds: -

Wounds of the vein give rise to hemorrhage of various degrees, aside from the hemorrhage, infection of the vein and phlebitis may ensue.

2-Air Embolism: -

When a vein is opened near the chest, air can enter the vein leading to air embolism, that may affect the coronary artery, pulmonary artery, or it cause heart failure when it is large enough.

Treatment:

Massage over the injured vein to permit escape of air with blood.

3-Phlebitis: -

It is inflammation of the vein that may predispose to thrombus formation.

1-Adhesive phlebitis

The vein appears as hard resistant cord, the peri-venus tissue seems edematous and pain is evident along the course of the vein

2-Purulent Phlebitis

Inflammatory symptoms are acute, abscesses may be formed over the vein that may form fistula, probing of the fistula may cause the probe to enter the vein.

3-Hemorrhagic Phlebitis

It is a complication of one of the fore-mentioned types of phlebitis or due to disturbance of the clot of the vessels. It is characterized by repeated hemorrhage.

Treatment:

1-Adhesive Form

a-Keeping the affected area at rest to avoid extension of the inflammation or disintegration of the thrombus.

b-Application of antiseptic for the wound of the affected vein.

c-Providing for drainage of the wound.

d-Application of counter irritant after the thrombus organized, to stimulate collateral circulation and to remove edema from the parts drained by the vein.

2-Purulent Form

a-Opening abscess.

b-Enlarging fistulous orifice.

c-Irrigation of the lesion by antiseptics.

d-Extirpation of the purulent vein.

3-Hemorrhagic Form

a-Plugging of the wound with antiseptic gauze to arrest bleeding.

b-Ligation of the vein.

4-Varicose: -

It is uncommon in veterinary practice. Usually it is on the ventral aspect of the abdomen or lower part of the leg.

Treatment:

a-Compression.

b-Firing the skin over the vein to act as a sort of permanent bandage.

c-Obliteration of the vein by injection with certain substances.

d-Ligation of the vein above and below the swelling and excision can be applied.

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AFFECTIONS OF MUSCLES

1-Open wounds of muscles: -

It is treated either it is recent or old wound.

2-Rupture of muscles: -

Muscle ruptures either partially or completely. Generally rupture of muscle is not common like that of tendons.

Causes:

It occurs in muscle as a result of severe contraction, or it occurs in the relaxed muscle as a result of severe contraction of the corresponding muscle.

Symptoms:

1-General symptoms of inflammation or hematoma.

2-Lameness.

Prognosis

*Slight rupture heals spontaneously and signs of inflammation and functional disturbance subside.

*Severe rupture is incurable as the muscle heals with formation of fibrous tissue that interferes with the normal function of the muscle.

Treatment:

1-Rest of the animal.

2-Applying the usual remedies of traumatic inflammation.

3-Muscular atrophy: -

It ensues as a result of

1-Disuse of muscle (during fracture).

2-Paralysis (injury of nerve).

3-After myositis.

Treatment:

1-Remove the cause.

2-Massage.

3-Application of counter irritants.

4-Exercise

4-Muscular spasm (Cramp): -

Muscular spasms are either

1-Tonic (continuous) like tetanus.

Tonic spasm of the muscle may ensues as a result of severe muscular exertion and it may be related to irritation of the nerve endings by the product of the fatigue muscle

2-Colonic (intermittent) like strychnine toxicity.

Symptoms

Affected muscles are rigid and painful especially muscles of the hind limb, and the hind limbs are directed caudally like patellar luxation.

Treatment

Applying cold douches and massage.

5-Myositis: -

a-Acute myositis:

1-Traumatic

It ensues as a result of trauma; the affected muscle is hard, thick and painful; lameness appears if the limb is involved; and treated by antiphlogestine.

2-Rhumatic

Observed in winter in neck, back, and limbs; affected muscles are tense, contracted, and painful; and pain is recurrent. It is treated by anti-inflammatory, local antiphlogestine, and massage.

b-Chronic myositis:

1-Chronic fibrous myositis.

2-Myositis eosinophilica.

3-Myositis chronica ossificans.

6-Tumors: -

7-Paralysis: -

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AFFECTIONS OF THE NERVES

1-Compression: -

Causes:

Pressure is the main cause as with radial or facial nerve

Symptoms:

Paralysis of the innervated muscles if the nerve is motor and loss of sensation if the nerve is sensory..

Treatment:

1-Application of counter irritants and massage over the nerve.

2-Supportive treatment (bandaging the limb).

3-Injection of nerve tonics (B12, Strychnine, or arsinical preparations).

4-Treatment of the affected muscle to avoid atrophy.

2-Contusions: -

Contusions usually affect superficial nerves

Cause: Mainly trauma.

Symptoms

1-Paralysis of muscles (motor nerve). 2-General symptoms of contusion and inflammation.

3-Pain at the nerve.

Treatment:

1-Promoting absorption of inflammatory exudates. 2-Analgesics.

3-Treatment of the paralyzed nerve and muscles.

3-Open Wound: -

Treatment: Suturing.

4-Tumors: -

5-Neuritis: -

It is inflammation of the nerve as a result of known cause as wound or infection.

Symptoms: Mainly pain.

Treatment

1-Analgesia.

2-Applying antiseptic preparations to the wound.

6-Neuralgia: -

It is a pain over the nerve of unknown cause.

Treatment:

Applying counterirritants over the course of the nerve.

7-Paralysis: -

The primary lesion may be in the brain, spinal cord or peripheral nerve. When the affected nerve is motor nerve, the innervated muscle has no ability to contract, and when the affected nerve is sensory nerve, the innervated region suffers from permanent analgesia.

Treatment:

1-Nerve tonics.

2-Counter irritants over the nerve and massage.

3-Application of usual remedies to the muscles innervated.

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BURNS AND SCALDS

Definition:

It is an injury of the skin and underlying tissues as a result of exposure to high temperature or chemical substances. When the etiology of burn is hot liquid or stem, the condition is called *scald*.

Etiology:

1-Heat.

2-Chimicals (acidic or alkaline).

3-Various forms of energy (light rays, ultraviolet rays, radiation, and electrical current).

Types of burns:

1-Burns grade I

This type of burns is characterized by injury of the superficial layers of the epidermis, burning pain, marked hyperemia, and moderate edema of the skin. An example is the mild sunburn, and the superficial layers desquamate and replaced by the deeper germinal layers.

2-Burns grade II

This type of burns is characterized by injury of the whole thickness of the epidermal layer and parts of the papillary layer of the skin. Burns that are caused by hot fluids or stem (in carnivorous animals) are characterized by blisters or vesicles of variable sizes filled with serous exudates. On the other hand, burns as a result of flame (in large animals) never show blisters, but edema of the subcutaneous fat can be observed.

3-Burns grade III

This type is characterized by injury of the all layers of the epidermis and papillary layer. The epidermis undergoes total charring, the papillary layer undergoes coagulative necrosis, and the subcutaneous fat undergoes edema, and the skin acquires rubber consistency. The necrosed tissue slowly rejected leaving shallow ulcers, but later on, it is covered by epithelium.

4-Burns grade IV

This type of burns is characterized by total charring of the superficial layers of the skin; coagulative necrosis of the skin through its depth; and necrosis of fascia, subcutaneous fat (with massive edema), and even the superficial muscular layers. The skin acquires shell appearance.

5-Burns grade V

This type of burn is characterized by charring and blackness of all soft tissues and even of the bone.

Pathogenesis:

Burns grade I and II are manifested by serous or serofibrinous exudation and epithelial regeneration occurs. While burns grade III to V are characterized by inflammatory reaction of purulent nature. Few hours after extensive burns, disturbance in circulation of paranchymatous organs, especially liver and lung, occurs. This disturbance might be due to vasodilataion of the peripheral blood vessels and increased permeability leading to edema and hypovolemia. The injured tissue easily invaded by bacteria leading to suppurative dermatitis. Finally, sepsis, toxemia, or shock (hypovolumic or toxic) ensues. Systemic reactions can be categorized as;

1-Kidney function as a result of hypovolemia and absorption of toxins.

2-Liver function.

3-Pulmonary affection as a result of inhalation of smokes.

4-Hem-concentration as a result of fluid and blood loss via skin

5-Shock and septicemia.

Treatment:

Aims of treatment directed toward relieve of pain, correction of circulatory disturbance, control of bacterial infection, and application of healing stimulants.

A-Local treatment:

1-Thorough washing if the cause of burn is chemical substance.

2-Removal of charred or necrotic tissue.

3-Evacuation of vesicles to allow escaping of its contents and to relieve pain caused by pressure.

4-The surface of burn can be swapped with

a-Tincture of iodine.

b-Saturated solution of picric acid (analgesic and antiseptic).

c-Tannic acid 2% in the form of jelly (astringent).

d-Anodyne antiseptic ointments like cocainised vaseline or iodeform ointment.

5-Topical antibacterial agents like dyes (gention violet), sulfa, or antibiotic preparations can be used for control of infection.

6-Solcoseryl ointment, panthenol ointment, or cod liver oil can be used to stimulate healing.

B-Systemic treatment:

1-Stimulants (hypodermic caffeine) to counteract the effect of toxemia and depression.

2-Antihistaminic (Avil) to counteract the effect of histamine.

3-Analgesics (cortisone for its analgesic, anti-inflammatory and antihistaminic effect aside from rising blood pressure). However, cortisone has side effects like immunosuppresion and delayed healing. One of the best analgesics anti-inflammatory to be used is Flunixine meglumine.

4-If the animal exposed to high amount of smokes, and signs of respiratory distress is present, bronchodialator can be used like minophyline, or even tracheotomy is indicated if the dyspnea is so severe.

5-Antibiotic to control infection.

6-Administration of fluid therapy to correct the hypovolemia. The best fluid therapy to be used is Ringers lactate. The dose and the rate of infusion are very important; the doses that can be used depend up on the degree of dehydration.

	Light dehydration	Moderate dehydration	Severe dehydration	Rate of infusion
Replacement dose	5%	8%	10%	10-20 ml/ kg/ hour
Maintenance dose	50 ml/ kg			2-4 ml/ kg/ hour

Prognosis:

*It depends on the extent of injury rather than the degree of burn, shock may ensue when more than 40% of skin involved, however, prognosis is unfavorable when more than 50% of the skin is affected.

*First degree burns may last 10 days for healing, while second and third degrees need 4 weeks or more for healing.

Bursa and Bursitis

What are Bursitis?

True bursitis, also called natural bursitis, is found in the conventional areas within the legs or withers, mostly centered on the joints. True bursitis is generally easy to diagnose and treat.

Acquired bursitis will develop subcutaneously in direct response to friction or pressure. A tear within the subcutaneous tissue allows fluid to build up and become trapped in the fibrous tissue surrounding it.

Bursitis is extremely common in horses. It is inflammation within the bursa and can be classified as either true or acquired. The bursa is a sac that is filled with fluid found between tissues of muscles, skin, tendons and bone. The fluid provides lubrication reducing rubbing, friction or irritation within the leg.

Symptoms of Bursitis in Horses

Bursitis, no matter its form, can be severe if not treated immediately. If you notice any change in your horse's behavior or see any physical changes, contact your veterinarian right away for an assessment.

- Swelling
- Localized heat
- Pain
- Lameness
- Tenderness
- Limited movement within the leg or shoulder
- Not eating or drinking
- Refusal to walk
- Behavior changes

Types

There are several different types of bursitis. Once your veterinarian has diagnosed your horse with bursitis, they will then be able to pinpoint which type and choose the best treatment plan for that particular type. Any of these types of bursitis can become septic, or have an infection begin if a bacterium has been introduced into the body.

Carpal Hygroma

This is classified as acquired bursitis and is caused by direct trauma to the knee. It usually occurs from lying on hard ground, hitting the knee against a hard surface, excessive and hard pawing or a fall. There will be severe swelling on the front of the knee, restricting the flexion of the knee.

Olecranon Bursitis

Also known as capped elbow, it is very similar to carpal hygroma. It is classified as acquired bursitis and is caused by trauma, usually from a shoe hitting the elbow when running or when lying down.

Calcaneal Bursitis

Also known as capped hock, it is classified as acquired bursitis. There is fluid buildup with the tissues causing possible lameness. Kicking a wall or gate is usually the cause of capped hock.

Cunean Bursitis

It is classified as true bursitis. This is mainly associated with an underlying condition called tarsitis. Tarsitis is inflammation within the lower hock joints, called the tarsal. Lameness generally occurs.

Navicular Bursitis

Classified as true bursitis, it can be considered a part of navicular disease. Lameness generally does occur and can have severe consequences if not treated immediately. The frog and navicular bursa are affected when a foreign object punctures the area and can cause infection.

Bicipital Bursitis

Classified as true bursitis, it is generally caused by an injury to the shoulder. Lameness is usually associated with bicipital bursitis. It may be from an injury to the bicipital tendon or from bone fragments that have broken from the shoulder.

Fistulous Withers

This is not common and is an infection of the bursa that overlays the withers. It causes swelling, drainage tracts and severe discomfort. Brucellosis can occur from fistulous withers.

Causes of Bursitis in Horses

Your veterinarian will do a thorough physical examination of your horse. During the physical examination, provide as much background information as possible including exercise routines and when you first noticed any oddities or symptoms.

After an initial examination, further testing may be required. A radiograph will confirm swelling and located any fluid buildup within the soft tissues. An ultrasound may also be used to see the extent of the fluid buildup and how much of the leg or shoulder is affected.

Once the presence of fluid has been determined, your veterinarian may take a biopsy or sample of the fluid. By examining the fluid, your veterinarian will be able to properly treat your horse if there is an infection present. Septic bursitis requires aggressive treatments.

Treatment of Bursitis in Horses

Your veterinarian will create an appropriate treatment plan for your horse depending on the affected bursa and the severity of the condition. Always follow treatment plans exactly as given and any changes within your horse's condition should be immediately reported to your veterinarian.

Rest will most likely be advised. Stall rest is always best with a thick layer of dry bedding for a cushion should your horse prefer to lie down. Pressure bandages or splints to help immobilize the affected leg may be used. Cold applications to the affected area will help reduce swelling. Cold applications work best in the early stages of acute bursitis.

Corticosteroid and anti-inflammatory medications may be used to help reduce swelling and eliminate pain. In cases of septic bursitis, aggressive antibiotics are needed to treat the infection. Surgical drains may need to be implanted if the fluid buildup is excessive. In some cases, removal of the bursa or closing the puncture is needed.

Recovery of Bursitis in Horses

In cases of true bursitis, the prognosis is good. For acquired bursitis, the prognosis is more guarded. Horses that are diagnosed with any form of septic bursitis may not recover even if treatment is begun immediately.

Always follow your veterinarian's set treatment plan for your horse. If you notice any changes or you are concerned that your horse is not responding to treatments, contact your veterinarian for additional assessments. Be sure to schedule all recommended follow-up visits so your veterinarian can closely monitor your horse's progress.

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CYST

Definition: -

It is a congenital or acquired hollow swelling or tumor like structure containing fluid, semi-fluid, or solid structures like hair or teeth.

Classification: -

I-CONGENITAL: -

A-Dermoid cyst: -

Commonly it is subcutaneous cyst and rarely observed in internal organs (ovary, testicle, or brain

1-Simple form: -

Contents: It is lined with epithelium and contains mucoid fluid.

2-Compound form: -

It is a Teratoma like cyst

Affected animals: Mainly calves

Location: The neck, entrance of larynx, or posterior part of lower maxilla

Characteristics: Wall is similar to skin (has hair follicle and sebaceous gland).

3-Follicular cyst: -

Affected animals: Foal

Location: Bony alveoli, especially the first molar teeth

Characteristics: It increases in size at age of one year.

B-Dentigerous cyst: -

Contents: Tooth

Affected animals: Foal

Location: At the temporal bone as a sinus opening anterior to ear base

Characteristics: Thick exudate comes out from the opening of the sinus and

when it is probed, the probe will strike the tooth

C- Tongue base cyst: -

Contents: Mucoid

Affected animals: Calves and foals

Location: Tongue base, larynx, or epiglottis

Characteristics: Pedunculated or not, and large cyst may interfere with mastication or causes dyspnea and asphyxia.

D-Umbilical cyst: -

Contents: Mucoid fluid

Affected animals: Calves and foals

Location: Umbilical region

Characteristics: Hen's egg to hand fist size

II-ACQUIRED: -

A-Traumatic epithelial cyst: -

Contents: Grey yellowish mucoid fluid

Characteristics: Caused by trauma or fire shooting with sequestration of piece of skin or foreign body at wound base with superficial healing of the wound.

B-Retention cyst: -

It is an acquired cyst formed as a result of obstruction of secretory duct of glands

1-Atheroma: -

Contents: Sebaceous

Affected animals: Horse

Location: Sebaceous gland of false nostril

Characteristics: It causes stenosis of nasal passage and respiratory noise

2-Mucous membrane cyst: -

Contents: Clear viscid mucoid fluid due to obstruction of mucoid gland

Affected animals: Cattle and horse

Location: Inner aspect lower lip and sublingual mucous membrane

Rectal mucous membrane of horse

Vaginal mucous membrane cow

Characteristics: Spherical or oval shape

3-Neck cyst, brachial cyst, ranula, and honey cyst: -

It is formed as a result of obstruction of mucous gland or duct of sublingual or submandibular salivary gland

Contents: Honey like thick yellowish saliva (So it is called *Honey cyst*)

Affected animals: Dog

Location: Besides fraenum linguae or tongue (So it is called

mouth cavity cyst or *ranula*)

Under larynx or upper part of neck (So it is called *neck cyst*)

Characteristics: Round or oval swelling with thin wall

C-Exudative cyst: -

It is formed as a result of accumulation of exudates in pre-existing cavity as in case of accumulation of fluid in tunica vaginalis after castration or ovarian cyst.

D-Parasitic cyst (pseudo-cyst): -

It is formed as a result of irritation of tissue by growing parasite wth formation of pseudo-cyst surrounded by fibrous tissue

Examples:

Coenurus cerebralis	Brain of sheep and cattle
Taenia cyst	Masseter muscle and heart in cattle and pigs

Echinococcus cyst (Hydatid) Kidney, liver, lung, spleen, and bone

E-Degenerative cyst: -

Causes:

1-Intramuscular injection of irritant drugs or chemicals that can't be absorbed

2-It associates tumors like cysto-carcinoma, cysto-sarcoma, or cysto-fibroma

Symptoms:

1-Localized swelling containing fluid (fluctuating), semi-fluid, or solid structures like teeth or hair (dentigerous or dermoid cyst respectively)

2-Slow growth rate and absence of inflammatory signs

3-Well defined periphery with absence of pathological lesion in skin covering the cyst

4-Sympytoms are confirmed by exploratory puncturing

5-Radiography diagnoses and confirms bone cyst

Diagnosis:

1-History

2-Clinical signs

3-Exploratory puncturing

4-Differential diagnosis

5-Radiography

Treatment:

1-Aspiration of contents by needle or trocar and cannula with injection of irritants like Tr. Iodine or 5% Carbolic acid to destroy secretory lining and to stimulate granulation tissue for obliteration of the cavity.

2-Surgical incision at lowest point and swap with Tr.Iodine to stimulate granulation tissue formation and obliteration

3-Seton may be used to stimulate granulation tissue formation and obliteration

4-Surgical excision

5-Pedunculated cysts of the base of tongue, vagina, or abdominal cavity can be removed by ecraseur to avoid bleeding

6-Ovariectomy or castration for removal of ovarian or testicular cyst

7-Hydrocoele can be treated by evacuation of fluid that is followed by castration

8-Dentigerous cyst can be treated by surgical excision, curetting, cauterization of the sinus, then closure of the wound with establishment of an opening at the lowest point for drainage

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FRACTURE

Definition:

Break down of bone continuity

Classification:

I-ACCORDING TO DEGREE OF DAMAGE: -

1-Incomplete fracture: -

A-Green stick fracture: -

It is a type of fracture affects long bones of young animals especially those with rickets. The increased pressure over the convex surface of the affected bone predisposes to fracture.

B-Fissure cracks or fissure lines: -

They are single or multiple fractures lines; parallel or not; of different directions (transverse, longitudinal, or oblique), of traumatic origin and usually affect flat bones like scapula.

C-Splint fracture (Splinter): -

It affects flat or long bone, ensues as a result of gun fire, the bone still intact, and the hole of the gun fire sometimes has cracks around it.

D-Differed incomplete fracture: -

It ensues as a result of neglecting incomplete fracture for a long period

2-Complete fracture: -

A-According to fracture line: -

i-According to number of fracture lines: -

1-Single line fracture: -

It is a fracture that divides the bone into two pieces

2-Multiple fracture or comminuted fracture: -

It is a fracture type where the bone is divided into more than two pieces.

ii-According to site of fracture: -

1-According to the location of fracture line on the bone: -

Fracture can be classified into epiphyseal, diaphyseal, or metaphyseal

2-According to the name of the fractured piece of bone: -

Fracture can be classified into condoiler, supracondoiler, articular, trochanteric, or inter condoiler

iii-According to the shape of fracture line: -

1-Longitudinal

Usually it affects short bones

2-Transverse

Usually it affects long bones

3-Oblique

B-According to fracture fragment: -

i-Overlapped fracture: -

It is a fracture in which the two fragments overlap each other and can be observed in case of oblique fracture

ii-Angled or angulated fracture: -

It is a fracture characterized by angle formation between the two bone fragments

iii-Lateral fracture: -

It is a fracture type in which the two edges of the fractured bone lies lateral to each other

iv-Spiral fracture: -

It is a fracture type characterized by rotation of one bone fragment around its long axis

v-Star shape fracture: -

It is a fracture characterized by presence of cracks around the gunfire giving it star shape

vi-Wedged or impacted fracture: -

It is a fracture a fracture characterized by no displacement with wedging of the two fractured fragments like wedge or like suture of flat bones of skull

vii-Depressed fracture: -

It is a traumatic fracture of flat bone over a cavity leading to displacement of a disc of bone into this cavity, like frontal bone.

viii-Compressed fracture: -

It is a fracture with shortening and thickening of the bone as that with vertebrae

ix-Destructed fracture: -

Fracture characterized by wide separation of the bone fragments due to pulling action of ligament like fracture of patella

II-ACCORDING TO SITE OF FRACTURE: -

As mentioned before

III-ACCORDING TO COMPLICATIONS: -

1-Simple fracture: -

It is pure bone fracture with no complications

2-Compound fracture: -

It is fracture with skin injury (wound)

3-Complicated fracture: -

It is fracture associated with injury to nerve (like radial paralysis), artery or vein, opening of a joint, opening of a body cavity (like chest)

Causes:

I-EXITING CAUSE: -

1-Extrensic forces: -

A-Direct violence: -

Like falling from high places, car accidents, violent beating of an animal with strong stick

B-Indirect violence: -

The site of trauma is far from the site of fracture as falling on leg with fracture of the back (compression) or pelvic bones, twisting of hand with fracture of shoulder bones,

2-Interinsic forces: -

A-Severe muscular traction during racing

B-Bone diseases: -

Cancer, rickets, or osteomalasia

II-PREDISPOSING CAUSES: -

1-Heriditary: -

2-Age: -

The incidence of fracture is higher in young animals, and heavy animals

3-Sex: -

During sexual intercourse, females are more susceptible to pelvic fracture, while males are more susceptible to fracture of hind limb

4-Nuteritional: -

Low calcium and phosphorus, high vitamin A, high fluorine, and high carbohydrate with obesity

5-Hormonal: -

Hyperthyroidism increases blood Ca and P and reduces them in bone

6-Aim of animal use: -

Galloping, jumping, drafting horses are more susceptible to fracture than show or fantastic horses

7-Nature of land: -

Fracture is less frequent on soft land and its incidence increases on slipary or hard lands

8-Animal temper: -

Fracture is less frequent in calm animals and more frequent in vicious animals

9-Animal condition and diseases: -

Cancer or skinniness predisposes to fracture

Symptoms:

I-LOCAL SIGNS: -

1-Pain, restlessness, and laying down 2-Swelling 3-Function impairment

4-Abnormal position of bone 5-Abnormal sound (crepitate) 6-Abnormal motility

7-Albiumenurea

II-SYSTEMIC: -

Traumatic fever and anorexia

Diagnosis:

1-History

2-Clinical examination (local symptoms and crepitation)

3-Radiography for small animals or appendages of large animals

Healing:

1-Pathologic classification: -

A-Soft callous: -

i-Stage of hematoma (1-3 days) ii-Stage of tissue granulation (5 days)

iii-Stage of ostoid tissue formation (5-7 days)

B-Hard callous: -

i-Stage of consolidation (3-5 weeks) ii-Stage of osseous tissue formation (6 months)

iii-Stage of remodeling

2-Clinical classification: -

A-Temporary callous

B-Soft callous: -: -

Bleeding occurs during fracture with accumulation of inflammatory exudates leading to swelling. The fluid is reabsorbed, and blood under goes clotting with fibrin net formation. Later on angioblasts and fibroblasts appear for granulation tissue formation from the periphery toward the center. This process is associated with condrogenic changes (formation of cartilage) and ostoid tissue formation by osteoblasts with calcium deposition.

C-Hard callous: -

It starts with consolidation and characterized by calcium deposition under control of blood calcium level, and gypsona can be removed 3-5 weeks later. Osseous tissue formation and remodeling occur during this stage with union of the bone fragments, conversion of ostoid tissue to osseous tissue, and formation of haversian system (it lasts 6 months). Osteoclasts lyses the external and internal callous with precipitation of calcium form outer to inner parts of the intra-fragmental callous.

Factors affecting healing: -

1-Age: -

The younger the age the faster the healing (2-3 ws in young and 3-5 ws in old animals)

2-Individuall variation: -

3-Nutrition: -

Qualitative or quantitative reduction in food ingredients prolongs healing time

4-Cause: -

Traumatic injuries is characterized by temporary hematoma followed by rapid healing, while infection of fracture site causes destruction of the granulation tissue with prolongation of healing time.

5-Site of fracture: -

Epiphyseal fracture of spongy bone heals faster than fracture of compact bone

6-Shape of fracture: -

Oblique or longitudinal fracture is better than transverse fracture, also single smooth fracture is better than multiple fragmented granulated fracture.

Non union and delayed union of fracture: -

1-Wide separation 2-Incarciratin of soft tissue between fragments

3-Some diseases (rickets or osteomalasia) 4-Infection or osteomylitis

Prognosis: -

1-Age and species variation: -

Old animal has bad prognosis due to

-Difficult reduction of fracture -Difficult immobilization

-Prolonged healing -Increased possibility of complications by movement

-Stiffness of joints and cartilaginous degeneration due to prolonged healing

-Muscular atrophy and fatigue due to prolonged healing

-Skin necrosis and ulceration due to prolonged healing

-Soft tissue edema due to prolonged healing

-High possibility of reactions in the sound limbs (tendonitis, arthritis, and deformity)

-Deformity of fractured limb

2-Aim of use: -

Draft and racing horses cannot be treated but valuable animals can be treated and used for breeding

3-Economic value of the animal and cost , and relation between animal and owner: -

Low price animals should be condemned if the cost of treatment is high, while pets are treated whatever the cost. Pets and horses should be treated wt ever the cost

4-General condition of the animal: -

a-Fracture site and shape of fracture: -

Forelimb fracture has better prognosis than hind limb, and fractures below carpus and tarsus is better than higher fracture due to easier fixation.

b-Sex of the animal: -

Female fractures have better prognosis than male fracture due to quietness of the female.

c-Duration: -

The more recent the fracture the better the prognosis

d-Complications: -

Simple non-infected fracture has better prognosis

Treatment:

1-Primary treatment: -

A-Prevention of shock due to pain by analgesics

B-Prevention of further damage due to movement

C-Prevention of change of simple fracture to compound due to movement

2-Secondary treatment: -

A-Reduction of fractured bone to approximate normal position: -

It should be done as soon as possible before numbness and pain, spasm, and swelling, as pain causes muscular spasm.

Technique:

These steps should be done after good straining of the animal with application of general anesthesia as local analgesia retard healing. The aim of anesthesia is to relieve pain, and induction of muscular relaxation. Later on extension and counter extension by an assistant should be done to bring the bone fragments in one level. Finally X-ray should be done to ensure the normal positioning of bone fragments.

Types of reduction:

i-Closed reduction: -

It is performed with the skin closed (intact skin)

ii-Open reduction: -

The bone fragments are reduced to normal position surgically with inscising the skin aseptically

B-Fixation and immobilization till complete union of bone: -

The bone fragments and the joints upper and lower to the fractured bone should be fixed till complete union of fracture

Types:

i-External fixation: -

The joints upper and below the fracture should be fixed, and sometimes all the limb is fixed

Advantages:

-Cheap and easy method

-It doesn't need high experience or complicated equipment

-There is no possibility of infection

Disadvantages:

-Pressure necrosis

-Joint problems and stiffness, and muscular atrophy due to prolonged fixation

Types:

1-Ordinary splints: -

It must be cheap, light weight, malleable, and has length greater than the distance between the two joints, like metal, wood, leather, or even cartoon in birds or pets. At least two splints (medial and lateral) are needed for proper fixation.

Application:

-The joints above and below the fracture should be involved and fixed, and sometimes the entire limb is fixed.

-Application of enough cotton padding to avoid direct pressure on skin and subsequent necrosis and gangrene, and to make the animal more comfortable, but very thick padding decreases the fixation. Cotton should be inserted between claws or fingers, and should be at levels beyond the splint.

-Splints are applied medial and lateral to the limb

-A gauze tapping should be applied over the splints

2-Casts: -

-Example of casts is the Gypsona or plaster of paris. Other types of casts are plastic or fiberglass casts and they are stronger and not affected by moisture but they have no pores leading to heat stasis and sweat stasis with final maceration of the skin.

Advantages:

-Cheap, easily applied, and has no local complications

Disadvantages:

-Affected by moisture and need long time to reach its maximum hardness (24 hours)

Application:

-Application of bandage by padding with cotton and tapping with gauze as mentioned before

-Application of gypsona, then leave the animal for 0.5 hours to hardening of gypsona

Postoperative care:

-The cast should be observed for cracking, presence of discharge (color), odor, and swelling

3-Thomas tube: -

It is a metal tube of two rings (upper wide with a diameter 1 inch more than the thigh, and lower narrow), and two lateral splints longer than the limb. A modified Thomas tube with bent side splints is used for the hind limb.

ii-Direct skeletal fixation: -

This method is a mixture of external and internal methods of fixation. It is not applied directly on bone, and the bone itself is fixed externally without incising the skin by using pins that pass percutaneous from bone cortex to the opposite cortex and the pins are fixed outside by frame. The pins should be sterile, and of non-corrosive or ionized substances like stainless steal, platen, or cobalt nickel. Examples are standard splint, Keurs slimmer splint, and Ehmar splint.

Advantages:

-No joint fixation thus avoids complications of joint affects and muscular atrophy

-No hindrance of circulation

Disadvantages:

-High incidence of infection

Application:

Under aseptic condition, the pins are driven percutenously into muscles, perosteum, and the two cortexes. It is better to drive the pins in two different angels for better fixation.

ii-Internal fixation: -

Direct fixation applied to bone itself

Advantages:

-Better method because it fixes the bone itself without involvement of the joint

-It produces accurate reduction as the skin and muscles are opened

-It has no circulatory hindrance or pressure atrophy

Disadvantages:

-High incidence of infection and inflammation, and destruction of bone marrow

-Pressure of the splint on bone

Used materials:

-From clinical point of view it should be of high strength, non-corrosive, not rusting, and not ionizing

-From economic point of view it should be cheap like stainless steal (it is the best), ceramic, nickel, or cobalt

Types:

1-Extramedullary: -

a-Screw pin fixation: -

Indications:

-Fractured extremities, head of bone, neck, or condoiles

Technique:

-Control of the animal

-General anesthesia and aseptic precautions

-Open reduction of fractured bone

-Drilling of bone fragments and screw pining through the entire thickness of the fractured fragments

-Closure of wound in layers

-Removal of the pin after complete healing

b-Circular wiring or bone suturing: -

Indications:

-Treatment of fractured flat bones (jaw, scapula, etc…)

Technique:

-Control of the animal

-General anesthesia and aseptic precautions

-Open reduction of fractured bone

-Drilling of bone fragments with suturing of fragments with simple interrupted wiring by stainless steal wire

-Closure of wound in layers

-Removal of wire after complete healing

-This method can be used with other methods like screw pining

c-Bone plating: -

This method can be applied by using metal plate that has the same bone convexity and fixed with 4-6 pins

Indication:

Diaphysial fracture of long bones

Disadvantages:

-Exposure of large area of the bone and tissue that predispose to infection

-The plate is applied directly on the bone that predisposes to necrosis

Technique:

-Control and general anesthesia

-Aseptic technique guide

-Open reduction of the bone fragments, exposure, and fixation by plate and pins

-Closure of the wound in layers

2-Intramedullary pinning: -

Fixation is done here through the medullary cavity of the bone. It can be applied to diaphyseal fractures of long bones but metaphyseal fractures are treated by screw pins

Advantages:

-Proper reduction and fixation of the bone fragments

-Joint, muscles, and blood supply not affected

Disadvantages:

-Bone marrow destruction

-Infection and osteomyelitis

Types of pins:

-Steinman pin that is straight and round in cross section (The best)

-Keutschner pin that is straight and triangular in cross section

-Rush pin that is bent near its wide end

Indications:

Fractured long bones, but cant be used for comminuted fractures, multiple fractures, infected fractured, or metaphyseal fractures

Technique:

-Control and general anesthesia

-Aseptic technique guide

-Open reduction of the bone fragments

-Insertion of the pin along the bone through medulla, and the excess length is removed by saw, or the pin is inserted in retrograde manner

3-Bone grafting: -

It can be used when here is no union of bone fragments or for comminuted fractures

a-Auto bone grafting: -

A piece of spongy bone is removed for healthy bone of an individual, fragmented, and transplanted to the fracture site of the same individual

b-Homo bone grafting: -

The same is performed for an animal to another animal of the same species

c-Hetero bone grafting

The same is performed for an animal to another animal of another species

Treatment of compound fractures: -

-The principle here is to treat the fracture and the wound as soon as possible with control of infection

-Fixation, internal and direct skeletal fixations have no problem for the wound, while external fixation interfere with monitoring of the wound, so 8-Figure gypsona should be applied to leave a window for wound monitoring

-The wound is treated as usual through the window in the gypsona

C-Preservation of normal function of muscles, tendons, and joints: -

Complications of fractured: -

1-Pressure necrosis, muscular atrophy, and joint stiffness due to pressure of the fractured fragments

2-Damage of artery or vein due to movement of splint

3-Improper reduction and fixation

A-Gangrene due to direct pressure of splint on skin or tissue, impairment of circulation, or thrombi of the main blood supply. Signs of gangrene appear 24-48 hours later on in the form of;

-Local signs: - Bad odor, swelling, and greenish discharge,

-Systemic reaction: - Fever and anorexia

Treatment should be applied as soon as possible by removal of splint and application of hot antiseptic fomentations to enhance circulation, but if gangrene appeared, amputation will be the main treatment.

B-Faulty callous formation and can be prevented by proper fixation

C-Failed callous formation due to low calcium level, infection, improper fixation

D-False joint due to soft tissue between the two fragments with outer fibrous connective tissue connecting the two fragments. Cartilage may be formed beside the soft tissue, it can be treated by removal of fibrous connective tissue, soft tissue, and cartilage, refresh the bone surfaces by scraping, then make proper fixation

Conclusion:

-Fractures of the scapula and pelvic bones: -

Can't be treated

-Fractures of the shaft of femur and humorous: - It can be treated by intramedullary bone pining, bone plating, or direct skeletal fixation

-Fractures of the extremities of femur and humorous: - It can be treated by internal fixation by screw pin

-Fractures of extremity of radius, ulna, tibia, and fibula: - It can be treated by screw pining, internal fixation, or external fixation (Thomus or modified Thomus)

-Fractures of shaft of radius, ulna, tibia, and fibula: - It can be treated by intramedullary bone pining, direct skeletal fixation, splint and cast, or external fixation (Thomus or modified Thomus)

-Carpus, tarsus and downward: - It can be treated by cast or splint

-Skull and flat bones: - It can be treated by suturing; interalveolar wiring pf check teeth, bone plating, direct skeletal fixation for ramus; and wiring, bone pinning, or screw pining for factiures of mandibular body

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JOINT AFFECTIONS

1-Arthritis: -

Definition:

Inflammation of the joint including; bones forming the joint, articular cartilage, joint capsule (outer fibrous and inner synovial), and periarticular, collateral, intra-articular ligaments

The synovial fluid secreted by the inner synovial layer increases during inflammation, while pulling of the attachment of the fibrous layer of the capsule predisposes to periostitis and new bone growth formation. The normal synovial fluid has four properties: constant load bearing; lubrication and wetting of surfaces; good heat conductivity; and elasticity and ability to become semisolid on impact to prevent squeezing out from between articular surfaces and to prevent friction. The cartilage has low tendency to regenerate and consists of deep narrow calcified layer, broad intermediate high water content layer for shock absorption, and very narrow superficial layer of collagen that resists shearing and joint motion. Destruction to the cartilage may predispose to ankylosis. Arthritis is either primary (direct trauma, or infection with penetrating wound) or secondary (rickets, poor conformation, or localized systemic infection). Trauma or infection causes acute inflammation of synovial membrane, increases synovial secretion, and lowers synovial viscosity, leading to further

destruction of the articular cartilage aside from the destruction produced by the destructive enzymes of bacteria. Enlargement of the joint may be due to enlargement of the bones, thickening of the joint capsule, distention of joint capsule with synovial, or swelling of the periarticular.

Classification of arthritis by activity: -

a-Acute arthritis: - It causes severe inflammation of the joint with the traditional signs of inflammation, and it either resolves leaving normal joint, or develop into chronic inflammation with more destructive changes.

b-Chronic inflammation: - Low-grade inflammation of the joint that may exhibits acute flare-ups and always causes permanent damage of the joint.

Classification of arthritis by type: -

a-Serous or traumatic arthritis: -

It is a mild inflammatory change in the joint with no irreversible changes and characterized by inflammation of synovial membranes and increased synovial secretion leading to swelling and increased capsular pressure. Later on, erosion of the cartilage and osteoarthritis may develop. The main causes of the disease are; *trauma* (direct or poor conformation) that may be associated with sprain of associated ligaments; and *mild stress* on joint (poor conformation) that causes chronic serous arthritis with normal bony structures (radiographically). Serous

arthritis can advance to osteoarthritis or infectious arthritis. Infection reaches the joint due to aspiration, systemic localization, or injection with steroids.

Treatment: -

a-Acute phase

1-Rest, even by cast if there is sprain, or by bandage, bandage will induce counter pressure and support.

a-If the injury is mild, two weeks later, hot bags and liniments can be used to stimulate mobility.

b-If the injury is severe, 4-6 weeks later, hot bags and liniments can be used to stimulate mobility.

2-Local analgesia and sedation during acute phase to reduce pain.

3-Antiphlogestics.

4-Intra-articular and systemic corticoids.

b-Chronic phase

1-Intra-articular corticoids.

2-After control of inflammation, heat, liniments, and exercise should be used to stimulate motion.

3-Blistering, firing, radiation, or diathermy, but it is contraindicated to use ultrasound.

4-Rest for 1-6 months.

Prognosis: -

*Favorable if it is not chronic and there is no bone change.

b-Osteoarthritis, osteoarthrosis, hypertrophic arthritis, or degenerative arthritis: -

It is a common affection of old horse and it is either primary (intrinsic degeneration of the articular cartilage) or secondary (predisposed by trauma causing the osteoarthritis to supervene other pre-existing types of arthritis like serous arthritis). The disease begins either in the cartilage or the bone and usually it is non-inflammatory and characterized by deterioration of the articular cartilage and joint surfaces (degeneration of the cartilage and hypertrophy of the bone), and thickening of synovial membrane that may develop villi. The disease causes irreversible joint changes and treatment directed toward prevention of further damage. Animals with serous arthritis may develop osteoarthritis due to repeat trauma. Radiographically, the joint has uneven joint space and hypertrophyic new bone growth. Osteoarthritis may develop to infectious arthritis, or ankylosis at late stages due to damage of cartilage and hypertrophy of the bone.

Treatment: -

As it is usually chronic form of inflammation, it is treated by

1-Counterirritation like blistering, firing, irradiation.

2-Arthrodesis (surgical fusion of affected joint).

Prognosis: -

*Guarded to unfavorable.

c-Infectious, suppurative, or pyogenic arthritis: -

It is suppurative or non-suppurative inflammation of the joint, ensues as a result of injection, open wound, extension of infection from neighboring areas, or blood-borne infection. It is characterized by synovitis and destructive lesions of the joint (distension of joint with pus or abnormal infected synovia, heat, pain, fever, and acute lameness). Cartilage, bone, and synovial fluid can be destroyed by enzymes of bacteria or leukocytes, and accordingly the arthritis can advance to osteoarthritis or ankylosis. Radiographic changes ensue few weeks after affection and characterized by sunburst effect, the time at which the affection is considered chronic.

Treatment: -

One should keep in mind that infectious arthritis for more than one week predisposes to closure of blood supply with formation of septic focus to which antibiotic can never reach via blood stream or topically.

1-Evacuation of the joint form infected synovial, followed by intra-articular anti-biotic injection, and treatment should be continued for 10-14 days. Rest and bandaging of the joint. After control of infection, heat therapy and exercise should be used to promote motion.

2-Surgical treatment, that is directed toward drainage, and excision of infected bone and septic foci.

Prognosis: -

*Guarded.

d-Ankylosis or adhesive arthritis: -

It ensues as a result of osteoarthritis, infectious arthritis, or fracture and severe injury to the articulation. Characterized by destruction of the articular cartilage, erosion of the joint surface, flattening of the underlying bone, bridging of the joint by new bone growth, and absence of joint space at late stages.

e-Metabolic bone disease, or rickets: -

Primary disease of epiphyses of young horses up to 3 year-old ensues as a result of poor conformation. May be associated with forward knuckling of the fetlock joint (as a result of contraction of tendons and pain in the epiphyses); rachitic ringbones; enlargement of epiphyses of carpal, fetlock, and hock joints; wide epiphyseal line; and demineralization (osteoporosis) of the bone in severe cases that may predispose to fracture or deformity of the bone. There is no new bone

growth, lipping of the joint, or destruction of cartilage in early stages. Other affections that may develop as a result of rickets, are Bog spavins; windpuffs of fetlock, flexor tendon sheath, and carpal sheath.

f-Neoplastic arthritis: -

Like chondrosarcoma.

g-Villous arthritis: -

Finger-like growths from synovial membrane and associates other types of arthritis like serous, infectious or osteoarthritis.

2-Joint mice: -

Definition: Bodies within the joint cavity as a result of splitting off of piece of cartilage, by fracture of arthritic osteophyte at the joint margin, or by chip fracture of bones. These joint mice either attached to the joint capsule or freely move.

Signs: Sudden onset and sudden disappearance of lameness.

Treatment: Surgical removal of the chip fracture as soon as possible to avoid injury to the articular surface.

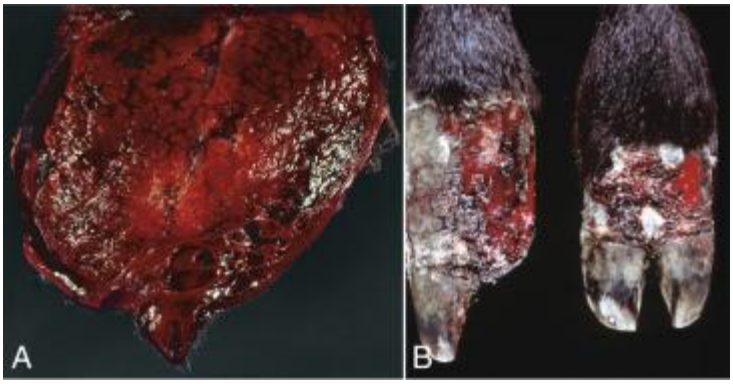
Prognosis:

*If the articular surface has extensive erosions, little improvement will be obtained after surgical removal of the joint mice.

Necrosis and Gangrenous

Gangrenous Necrosis.

Gangrene denotes a type of necrosis that tends to develop at the distal aspect of extremities, such as the limbs, tail, or pinnae, or in dependent portions of organs, such as the mammary glands or lung lobes. Gangrene can be designated as wet or dry; these forms are unrelated. If the dependent necrotic tissue is infected by certain bacteria, wet gangrene ensues. If those bacteria are gas forming (e.g., Clostridium spp.), then wet gangrene becomes gas gangrene. In the lung, wet gangrene is often a sequel to the lytic necrosis of aspiration pneumonia. The aspirated material could be foreign material (food or medicament) or gastric content (a mixture of ingesta and gastric secretions). Such materials can be caustic in their own right and are also likely to deliver bacteria from the environment or oropharynx into the lung. Staphylococcal infection of the ruminant mammary gland can result in gangrenous mastitis (Fig. 1-20, A; E-Fig. 1-3), a form of wet gangrene. Grossly, tissues with wet gangrene are red-black and wet. Histologically, the lesion of wet gangrene resembles that of liquefactive necrosis but is usually accompanied by more numerous leukocytes, especially neutrophils.



Gangrenous necrosis, or gangrene, is a potentially life threatening condition that has plagued humans for centuries. While it still occurs, it is not nearly as prevalent as it was hundreds of years ago. This lesson will discuss the types, causes, and treatment of gangrene.

What is Gangrenous Necrosis?

Let's take a trip back to the Civil War. Imagine a makeshift surgical tent near the battlefield. When injured, soldiers would be evaluated. Those with severe injuries were placed in one section, likely to die. Those with injuries to their extremities had better odds and would often receive an amputation (or removal) of the damaged limb. Doctors didn't wash their hands, wore clothes soaked in blood and pus, and their instruments were cleaned using cold water that was contaminated with blood. If the patient were lucky, he would heal. Unfortunately, the wound was likely to become infected. One such condition that plagued injured soldiers during the Civil War was gangrene. It would begin with a small, black spot on the healing tissue, and then would spread. Most of the time, the soldiers who acquired gangrene would die.

Today surgeons use sterile instruments, but gangrene still exists. Its technical name is gangrenous necrosis, and it is simply the death of tissues due to insufficient blood supply. There are different types of gangrene, so let's investigate each type.

Causes and Types

There are two main types of gangrene: dry and moist/wet. We will highlight a couple of additional types of gangrene as well.

Dry Gangrene

The first type of gangrene is called dry gangrene, and it occurs when the blood supply is slowly reduced to an area. It is often seen in people who have another condition, such as atherosclerosis or diabetes. In both of these conditions, the blood vessels are damaged, which causes a reduction of blood flow to certain areas of the body, such as the fingers, toes, and tip of the nose. While it usually isn't painful, the tissues eventually die and become cold, shriveled, and dry (hence the name ''dry gangrene''). The affected tissues are often said to look mummified. In dry gangrene, the tissues die, but there isn't a bacterial infection, which makes it less dangerous than moist/wet gangrene.

Moist/Wet Gangrene

Moist (or wet) gangrene is caused from a sudden reduction in blood to the affected tissues. This can be due to a traumatic injury, frostbite, or a blood clot. It might start by looking bruise-like, but the tissue eventually is destroyed, and deadly toxins from bacteria are released into the blood stream. Moist/wet gangrene is very painful, and it gets its name because pus is often released making it look ''wet.''

Internal Gangrene

Internal gangrene is caused by the reduction of blood to an internal organ, usually the colon, intestines, appendix, or gallbladder. For example, sometimes an injury called a hernia can occur. In some hernia cases, a piece of intestine will pop through a weakened part of the abdomen and get pinched off, thus reducing blood flow, which eventually results in internal gangrene.

Gas Gangrene

Gas gangrene occurs when a specific bacteria, Clostridium, invades an area where the blood supply has been reduced. For example, in the Civil War, a solider might have been injured, resulting in a reduced or eliminated blood supply to a certain body part. During the injury, or during the subsequent surgery, the wound could have become infected with Clostridium, and the bacteria would have eaten the tissue and produced toxins. Gas gangrene usually occurs deep in the tissues and gets its name because the bacteria produce gas.

Treatment

The treatment of gangrene depends on the type and the cause. Obviously, we have come a long way from the death sentence of gangrene during the Civil War, but even today gangrene can be deadly. The goal of treatment is to remove the dead tissue and treat the infection. Let's look at some treatments.

Surgery

Surgery is often utilized to remove the dead tissue in dry and wet gangrene. Depending on the severity, a small portion of tissue or an entire limb is removed. In internal gangrene, the organ's dead tissue is removed.

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SPRAIN AND STRAIN

1-Sprain: -

Definition:

Damage to ligamentous fibers or its attachment to bone as a result of overstress.

Classification:

a-Mild sprain:

Few fibers have been torn, mild hemorrhage, and no actual functional loss.

Treatment:

Unimportant and aimed at control of pain and rest

b-Moderate sprain:

Some fibers have been torn (varies from small tear to complete avulsion), no wide retraction of the two ends, some hemorrhage, and some degree of functional loss.

Treatment:

Same as mild sprain with protection to permit healing

c-Severe sprain:

Complete loss of function, hemorrhage, and wide separation of the ends

d-Sprain fracture:

Avulsion of a portion of a bone to which the ligament is attached

Treatment:

Severe or fracture sprain can be treated by apposition of the injured ligament to assure a ligament of normal length and strength, with application of cast for 6 weeks.

2-Strain: -

Definition:

Damage to a tendon or muscle as a result of overstress or overuse.

Classification:

a-Simple strain:

Low-grade inflammatory reaction with swelling and edema, but there is no appreciable hemorrhage, and it can incapacitate animal from work.

Treatment:

1-Relieve of the acute condition by local analgesics and corticoids

2-Ultrasound, local heat and protection

b-Violent strain or musculotendinous injury:

It is an injury to the muscle and tendon as a result of one violent injury, and it may be associated with tendonitis, tenosynovitis, or tendosynovitis. The tendon may be torn from bone, and the musculotendinous junction may be rupture or under go tearing.

Treatment:

Surgical repair of ruptured musculotendinous junction or severed tendon (wound), followed by application of cast with corrective showing.

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SUTURE MATERIALS AND SUTURE PATTERNS

I-Needles

A-Classification according to the eye: -

1-Closed eye needle: -

It resembles the household sewing needle with one or two eyes. Double strand of the suture passes through the tissue and causes much trauma.

2-Swaged-on needle (Eyeless or A traumatic needle): -

It is permanently attached to the suture, and cause minimal trauma of the tissue.

B-Classification according to the body or the shaft: -

1-Straight needle or Lomgstemmed needle: -

Like flessa needle or household sewing needle. It is no longer be used.

2-Half curved needle: -

Half of the needle is curved and half is straight.

3-Curved needle: -

It is either ¼, 3/8, 1/2., or 5/8 circle. It is the most famous used type.

4-Hock needle (Heavy bound bodied): -

The needle resembles hock.

C-Classification according to the point and the shaft: -

1-Conventional cutting or conventional sharp needle: -

The point is sharp with the cutting edge being provided at the concave surface.

2-Reverse cutting or reverse sharp needle: -

The same as above but the cutting edge is provided on the convex surface to minimize cutting of the tissue.

3-Taper cut needle: -

The point is cutting but the body is round.

4-Non-cutting needle (round needle): -

The point is round and the body is oval, and it causes minimal traumatization of tissue.

5-Blunt point needle (Ethiguard blunt taperpoint): -

The tip of point is blunt.

6-Spatulated needle: -

This type of needle has wide body in relation to the length of the needle and it has two cutting edges.

II-Suture materials

Suture materials are those filaments used to suture the edges of the wound to permit healing. They should maintain their strength until the wound has healed, have minimal tissue reaction, not favorable for bacteria growth, non-capillary, non-allergic, non-carcinogenic, easily handled, with good knot security, and cheap. Unfortunately, ideal suture material has not been found yet and surgeon should be familiar with advantages and disadvantages of suture material to be used.

A-Absorbable suture materials: -

1-Surgical catgut: -

It is a popular cheap suture material of collagen obtained from the submucosa of sheep or serosa of beef intestine, sterilized by gamma radiation and preserved in 85% alcohol, and can't be re-sterilized. Plain catgut loses its strength rapidly (3-7 days) and so it can't be used in certain regions. Chromic catgut is obtained by exposure of plain catgut to chromium salts, that increases strength of the filaments, decreases tissue reaction, and prolongs duration of absorption (10-20 days). Rate of absorption increases when the diameter of the filaments is small, if the suture exposed to gastric enzymes, if infection is present, and when the region has great blood supply. As the knot-holding ability decreases when the suture material is wet, the ends should be left slightly longer to minimize the chance of knot untying. However, this type of suture material is a protein and has high tissue reaction when compared with synthetic forms.

2-Collagen: -

It is a natural suture material related somewhat to catgut, and obtained from the flexor tendons of steers. It is smoother, causes less inflammation than catgut, more uniform than catgut, has less fray tendency, and used mainly in ophthalmic surgery.

3-Polyglycolic acid (Dexon®) and Polygalactin 910 (Vicryl®): -

They are synthetic, polymers, multifilament, containing no proteins, absorbable suture materials, and have minimal tissue reaction when compared with catgut. They handle like silk and do not swell when they are wet. They drag through tissues and cut soft organs, so they are coated with absorbable lubricant to make them smoother, however, dragging can be considered as advantage when continuous suture patterns are used, as the suture material will not be slide out of the tissue. Polyglycolic acid (Dexon®) is absorbed after 40-60 days while and Polygalactin 910 (Vicryl®) is absorbed after 90 days.

4-Polylactic acid: -

It is a mono or multifilament, synthetic polymer, absorbable suture material (over 1 year).

B-Non-absorbable suture materials: -

1-Silk: -

It is a protein filament produced by silkworm, braided, dyed, and coated with wax or silicone. It is used mainly for suturing of the skin, but it can't be used in infected wound because of its capillarity action. Its absorption is so slaw and when used internally it may last years to disappear. A synthetic form of silk was manufactured like Mersilk®.

2-Cotton: -

It is a plant origin filament that has a higher tissue reaction and higher possibility of infection than silk. On the other hand, the possibility of laceration is lower with cotton and so it is used mainly for treatment of vaginal or uterine prolapse (vaginal tape).

3-Nylon (Dermalon®, Ethilon®& Nurolon®): -

It is a synthetic, inert, polymer that has poor knot security. Monofilament (Dermalon®, Ethilon®) is preferred than multifilament when infection of the wound is expected although the multifilament braided nylon (Nurolon®) has some degree of roughness, better knot retention, and better handling properties.

4-Polypropylene (Prolene®) and Polyethylene: -

They are polyolefins that are usually represented in monofilament form. They have greater knot security and better handling than nylon. They are preferred than braided synthetic materials in infected wounds and can be absorbed over two years

5-Polymerized caprolactam (Supramid ®& Vetafil®): -

It is a synthetic multifilamentous suture material made from materials related to nylon and coated to minimized capillarity, so it can be used for suturing of skin but it has poor knot security compared with silk. Like all multifilamentous suture materials, it shouldn't be used in infected wounds.

6-Polyesters: -

It is multifilamentous polyester that consists of Dacron, which may be plain or uncoated (Mersilene® & Dacron®), Teflon-coated Dacron (Polydek®) or polybutylate-coated Dacron (Ethibond®), or Teflon-impregnated Dacron (Tevdek® & Ethiflex®). The uncoated form has more tissue drag, more capillarity action, and higher knot-holding ability than coated or impregnated forms. It must not be used in infected wound.

7-Stainless steel: -

It is a non-reactive, monofilament or multifilament of iron alloy (iron-nickel-chromium), difficult to be handled because it kinks, and it has good knot security but the knot tends to be bulky. It can be re-sterilized but it has great tendency for cutting the tissues or the gloves.

Considerations in choosing suture materials: -

1-Physical properties: -

a-Durability: -

Durability of the suture in the wound is affected by many factors like blood supply of the wound and infection. Tissues that have great blood supply or infection will get rid of the suture materials rapidly, so one should choose suture materials of low absorption rate.

Rate of healing and tension of the suture line affect the choice of suture material too, so the wounds with high healing rate and low suture line tension need less durable suture materials, while those with slow healing rate and high suture line tension, need more durable suture materials.

b-Handling ability and knot security: -

Good suture material should has good handling ability, minimal capillarity, and good knot security, unfortunately, there is no suture material yet has all phenomena.

c-Steralization: -

Most of suture materials are represented already sterile. However, autoclaving is a suitable method of sterilization of most suture materials (except for catgut), but multiple autoclaving for more than three times reduces the strength of the suture material. Gamma irradiation adversely affects polyglycolic acid and polypropylene. Ethylene oxide gas is a suitable method of sterilization of all suture materials.

2-Biological properties: -

Tissue reaction ensues as a result of traumatization of the tissue by the needle and dragging of the suture material, and by the chemical structure of the suture material. Thus, atraumatic needle with synthetic monofilament suture materials are preferred.

Monofilament suture materials are preferred than multifilament materials as the former has lower chance of keeping microorganism inside it than the later.

Most of synthetic absorbable materials hydrolyzed into chemical components that adversely affect multiplication of bacteria controversial to catgut.

III-Suture patterns

A-Basic suture patterns: -

1-Simple interrupted suture: -

It is a simple pattern by which the needle is inserted perpendicular at a right angle at one side of the wound (1 cm far from the edge of the wound in large animals and 3 mm far in small animals) and pass through the wound to the other side, so this pattern opposes the skin. This pattern is used n tissues that will not be subjected to a lot of tension.

Advantages

Advantages of this technique include its simplicity, opposition of the skin, and when a knot is untied, the other sutures maintain the strength of the suture line.

Disadvantages

Disadvantages of this technique include time consuming because of the high number of knots and consuming of large amount of silk material.

2-Simple continuous suture: -

It is the same as simple interrupted but it has only two knots, one at the beginning and the other at the end of the wound. This pattern is used n tissues that will not be subjected to a lot of tension.

Advantages

Advantages of this pattern include its simplicity, opposition of the skin, can be performed rapidly, and consumption of lesser amount of silk.

Disadvantages

Disadvantages of this pattern is that when one stitch is untied, the strength of the suture line can't be maintained.

3-Continuous lock stitch (Ford interlocking suture): -

It is a modification of continuous suture pattern. After the needle is inserted perpendicular on the wound and being drawn form the other side, it is drawn through the performed loop and tightened.

Advantages

Advantages include simplicity and opposition of the skin with relative maintenance of the strength of the suture line when one stitch is untied.

Disadvantages

Disadvantages includes that it is not as simple as the previously mentioned patterns.

4-Horizontal mattress suture: -

In this type of suture, the needle passes through the right side of the wound and drawn from the left side, then about 1 cm lower to the site where the needle was drawn, the needle reinserted and passes to the right side again, thus, two pieces of the silk can be seen parallel to the suture line. The needle should be inserted with angle through the skin to prevent eversion of the skin. This pattern can be used in an interrupted or continuous manner.

Advantages: -

It can be used in areas where much tension is placed on the skin.

Disadvantages: -

It interferes with blood supply to the skin and interferes with healing.

5-Vertical mattress suture: -

In this type of suture pattern, the needle is inserted 1.5 cm from the wound edge in the right side and passes through the wound and drawn 1.5 cm from the left side of the wound, then the needle is reinserted 0.75 cm from the left side (medial to the site where it was drawn) and passes to the right side through the wound, then it is drawn 0.75 cm from the wound edge (medial to the 1st bite). This type of suture can be used in areas where much tension is placed on the skin. Two silk lines perpendicular on the suture line can be seen, one on each side of the wound.

Advantages: -

It doesn't interfere with blood supply of the skin like horizontal type.

Disadvantages: -

It consumes much suture material and more time.

6-Cruciate suture (Cross mattress): -

In this type of suture, the needle is inserted 1 cm from the edge of the wound on the right side and passes to the left side and drawn 1 cm form the wound edge, then, the needle is inserted 1 cm below the 1st bite on the right side and 1 cm from the skin edge, and passes through the wound to the left side and drawn 1 cm ventral to the 2nd bite on the left side and 1 cm lateral to the wound.

7-Near-far-far-near suture: -

This type is a mixture of cross mattress and vertical mattress sutures. The needle is inserted 0.75 cm from the wound edge on right side and drawn 1.5 cm from the left side with 0.5 cm higher level, then the needle passes to the right side in the same level, and inserted 1.5 cm far from the wound edge, then drawn 0.75 cm from the wound edge (on the left side) at 0.5 cm lower level. Finally, two silk lines can be seen perpendicular on the wound, the upper long one is about 0.5 cm higher in level than the lower short line.

Advantages: -

It is a good tension suture.

Disadvantages: -

It is a time consuming suture.

8-Subcuticular suture: -

This type of suture is used to avoid the small scars produced around suture holes in other patterns. The needle is inserted into the subcutaneous tissue in the apex of the wound and passes to the other side and a knots is tied subcutaneously, then the suture is advanced like continuous horizontal mattress, but the needle is inserted in one side and drawn at lower level in the same side, the advanced to the other side and inserted then drawn at lower level till the end of the wound. No suture materials can be seen after suturing of the wound and the knots should be subcutaneous.

B-Suture patterns for hollow organs: -

Theses patterns are either opposing or inverting patterns and can be applied in as single or double rows. Single row patterns have high incidence of leakage, dehiscence, adhesion and peritonitis, while double row patterns associated with high incidence of stenosis. Whither single row or double row is the best, stills questionable.

1-Lembert suture: -

This pattern can be used in an interrupted or continuous manner. The needle passes through the serosa, muscularis and submucosa but it doesn't involve the mucosa. The needle is inserted perpendicular on the wound 0.8 cm from the wound and passes the mentioned layers then it is drawn 0.4 cm from the wound edge in the same side, then it passes to the other side and inserted 0.4 cm and drawn 0.8 cm from the wound edges. Only one line of the suture material can be seen perpendicular on the wound.

Advantages: -

It is the simplest pattern for the internal organs, relatively rapidly performed, inverts lips of the wound, and never involves the mucosa so the possibility of contamination is low.

Disadvantages: -

It produces slight stenosis of the bowel.

2-Halsted suture (interrupted Quilt): -

It is a modification of Lembert pattern. The needle is inserted perpendicular on the wound 0.8 cm from the wound edge of the right side and drawn 0.4 cm from the edge in the same side, then it passes to the left side (in the same level) then it penetrates 0.4 cm from the wound edge and drawn 0.8 cm from the edge. At the left side and with a lower level (0.4 cm) the needle is inserted 0.8 cm from the edge and drawn 0.4 cm, then it passes to the right side and inserted 0.4 cm from

the edge and drawn 0.8 cm. Two lines of suture material can be seen parallel to the wound (one on each side).

3-Interrupting inverting mattress suture: -

This pattern is similar to the horizontal mattress suture. The needle is inserted 0.5 cm from the wound edge parallel to the wound, penetrates muscularis, and passes downward for 0.5 cm, then drawn. At the same level where the needle is drawn (but on the other side of the wound) the needle is reinserted 0.5 cm from the wound edge, penetrates muscularis, and passes upward, then drawn at the same level of the 1st bite. Two lines of suture material can be seen perpendicular on the wound, parallel to each other's, and of the same length.

4-Cushing suture: -

It resembles inverting mattress suture but it is performed in continuous manner, and the mucosa is not involved. The needle is inserted 0.4 cm from the wound edge and passes parallel to the wound for 0.4 cm and drawn, and then it passes to the other side at the same level and re inserted in a manner similar to subcuticular suture.

5-Connell suture: -

It resembles cushing suture, but the needle passes all intestinal layers, so the possibility of contamination is higher.

6-Schemieden's suture: -

It is an inverting suture pattern that doesn't involve the mucosa. Stitches are brought through from inside the gut into the muscularis and drawn from the serosa.

7-Simple interrupted suture: -

It involves the mucosa and can be performed in two manners, either simple interrupted that doesn't interfere with circulation, or crushing manner that interferes with blood supply.

8-Gambee suture: -

In this pattern, the needle is inserted 0.5 cm from the edge of one side into the serosa and drawn form the mucosa, then it passes to the mucosa of the same side and drawn from the submucosa, then it passes to the submucosa of the other side, and drawn from the mucosa, then passes from the mucosa to the serosa.

9-Parker-Kerr oversew: -

It is a mixture of cushing flowed by Lembert pattern. A haemostatic forceps is applied perpendicular on the hollow organ, the organ is severed, then a layer of cushing is applied, the forceps is removed, then Lembert pattern is applied.

10-Purse string suture: -

This pattern can be used to close small holes used to evacuate gas from the bowel or to keep cannulae in situ, but it is mostly used with anus to retain rectum during rectal prolapse. The needle is inserted parallel to the anal opening, 1.5 cm far, and advances subcutaneously for 1.5 cm then drawn, then reinserted with the direction of watch 360 degree, then the two ends of the suture material are tied.

C-Suture patterns for severed tendons: -

1-Bunnell suture: -

Most of suture materials are kept inside the tendon to maintain the gliding function of the tendon and the suture is parallel to the tendon. Double round needle suture materials are used in this pattern. One needle is inserted at considerable distance from the edge of the severed tendon at right angle, then the needle is reinserted 0.2 cm far to this site in diagonal or oblique direction toward the other surface of the tendon and drawn at a point about 40% of the left distance, the same needle is reinserted 0.2 cm far and diagonally to be drawn at about 80% of the left distance and on the original surface. The other needle is advanced in the same manner, so finally an eight figure is formed inside one end of the tendon. All what u can see are four 0.2 cm long suture material parallel to the tendon (2 at each surface). In the other side of the severed tendon, the two

needles are advanced from the end of the tendon and in the same mentioned manner.

2-Locking-loop tendon suture: -

The needle is inserted through the cut surface of the tendon and advanced in the tendon to a considerable distance then drawn from one surface, at a point 0.3 cm lower and lateral to the point of puling of the needle, the needle is reinserted and passes perpendicular on the tendon then drawn from the same surface. The needle is reinserted 0.3 cm higher and medial to the point of drawing, and then the needle is advanced parallel to the tendon and drawn form the cut edge at the same level of the 1st bite. The needle is advanced in the other side of the severed tendon in the same manner and the knot is made in the cut surface of the tendon.

Tendon and Ligament Injury

1. Diagnosis of Tendon Injury

The most frequently injured tendons and ligaments in the horse are those on the palmar or plantar aspect of the distal limb. For this reason, this series of presentations will focus on these injuries. Diagnosis of strain-induced tendon injuries of the equine distal limb are based on history (usually a preceding period of exercise) and the development of the signs of inflammation (pain, heat, swelling, and lameness) over the affected structure. Confirmation and semi-objective assessment of severity is provided by diagnostic ultrasound.

2. Physical Examination

Lameness, which is often severe in the early stages, may not always be present when a patient is presented to a clinician, and it tends to be related to the degree of inflammation rather than the degree of damage. Similarly, after the inflammatory phase has passed in 1–2 wk, lameness usually resolves rapidly; however, the injury takes much longer to heal. Additionally, some tendon and ligament injuries do not follow this pattern. Deep digital flexor tendon (DDFT) overstrain injuries often remain persistently and markedly lame, and suspensory ligament (SL) desmitis, especially proximally in the hindlimb, can result in lower grade but persistent lameness.

Initial Examination—Non-Contact Observation

Observation of the limb before palpation can provide a considerable amount of information on the injured structure (nature and location of the swelling) and severity of the injury (alteration in the posture and function of the limb).

Swelling for superficial digital flexor tendon (SDFT) is most apparent when assessing the very palmar contour of the limb. It is often centered just distal to the mid-metacarpal region, but it can also be in the proximal metacarpal region (high bow) or distal within the digital sheath (low bow). In subtle cases, this swelling may only be apparent when the hair is clipped from the limb. Deep digital flexor tendinopathy rarely, if ever, occurs in the extra synovial portion of the tendon. Thus, injuries to this tendon are invariably associated with digital sheath distension and swelling in the pastern region. Desmitis of the accessory ligament of the DDFT (ALDDFT) occurs in the proximal one-half of the metacarpal region and is located immediately dorsal to the SDFT. It is often confused with DDFT enlargement, because it wraps around the tendon. Suspensory desmitis results in swelling over the affected area. It can occur proximally because of the presence of the splint bones; swelling may be minimal, especially in hindlimbs. It can also occur more distally in areas dorsal to the flexor tendons. Swelling of the body and branches of the SL is found

medially and/or laterally and is immediately palmar to the metacarpal bone.

Resting metacarpophalangeal (MCP) joint angle is often normal with superficial digital flexor tendinopathy because of the action of the other supporters of this joint (SL and DDFT). Additionally, pain will result in a reduced loading of the limb. However, in cases of severe superficial digital flexor tendinopathy, the affected limb shows greater than normal overextension of the MCP joint when the load on the limb increases (e.g., when the contralateral limb is raised or when walking). Severe damage to the SL will have a greater effect on MCP joint extension. ALDDFT desmitis rarely affects limb posture unless adhesions occur between it and the flexor tendons. In that case, the limb can take on the appearance of a flexural deformity.

Palpation

In a case of suspected flexor tendon injury, careful palpation of the tendons and ligaments in the limb should be made both when the limb is bearing weight and not bearing weight (flexed). When weight bearing, enlargement is assessed by comparison with the contralateral limb; however, bilateral disease is common. With the limb raised, the flexor tendons become slack. Careful attention should be given to pain response, subtle enlargement, which often manifests as an indistinct border to the tendon, and consistency of the structure (soft after recent injury and firm after healing). The horse must be relaxed so that muscle activity does not tense the tendons and make them appear artificially firm. This assessment should also include the contralateral limb, because many strain-induced injuries are bilateral; however, one limb is usually more severely affected than the other limb.

Swelling of the ALDDFT is detected by proximal swelling, usually predominantly laterally, because this is where the body of the ligament is situated. Enlargement is best identified with the limb flexed and palpated between the flexor tendon bundle and the SL in the proximal metacarpal region.

The same evaluation should be made for the SL. Unfortunately, the proximal region is impossible to palpate in the weight-bearing limb, especially in the hindlimb, because it is covered by the heads of the splint bones and the taut flexor tendons. The proximal SL in the forelimb can be palpated in the raised limb by moving the flexor tendons to one side and pressing between the heads of the splint bones. A comparison should be made between sides, because some normal horses may respond.

Percutaneous tendon injuries are usually associated with moderate to severe lameness and may or may not have a concurrent wound. If a wound is present, it should be initially cleaned and then explored digitally with sterile gloves to find the damaged structures. Small wounds may hinder full evaluation, because the tendon laceration site, sustained under full weight-bearing load, is unlikely to be visible in the wound when the horse is severely lame. In such cases, concurrent ultrasonographic examination is very helpful. Penetration injuries or partial severance of a tendon will not alter the function of the tendon, and therefore, other than lameness, there will be little alteration in limb conformation. Complete transection, however, is associated with significant alterations in limb conformation under loading.

SDFT is the overextension of the MCP joint under weight-bearing load.
SDFT + DDFT is the overextension of the MCP joint at rest and when weight bearing; the toe is elevated from the ground when weight bearing.
SDFT + DDFT + SL is the MCP joint on the ground.

If the laceration is complete, the proximal part of a lacerated tendon often recoils and can become reflected on itself. It is also necessary to assess if any synovial structures have been penetrated. This is a common complication of trauma to the distal limbs and will frequently lead to synovial sepsis.

3. Ultrasonography

Indications for Ultrasonographic Evaluation of the Tendon and Ligament Injuries

1. Diagnosis

Although most metacarpal/metatarsal tendon and ligament injuries are easily detectable by palpation, palpation provides a poor objective assessment of the severity. A base-line scan can provide an assessment of severity that may relate to prognosis. It is usually performed 7–10 days after injury, because injuries can worsen initially. In the pastern, however, non-specific fibrosis that commonly accompanies soft tissue injuries in this region makes accurate determination of the injured structure difficult. Therefore, ultrasonography is essential for establishing an accurate diagnosis in this region.

2. Management

Follow-up ultrasonographic examinations (ideally every 2–3 mo) are used to optimize management decisions during the rehabilitation phase.

Ultrasonographic Technique

The limb should ideally be prepared by clipping a strip of hair from the palmar aspect of the limb. For the proximal SL in the hindlimb, it is useful to extend this clipped area to the medial aspect to increase the size of the ultrasonographic “window.” The body of the SL is usually also evaluated from the palmar aspect; however, this only enables the axial one-third of the ligament to be examined. Therefore, a more complete examination can be achieved by increasing the clipped area for transducer place-

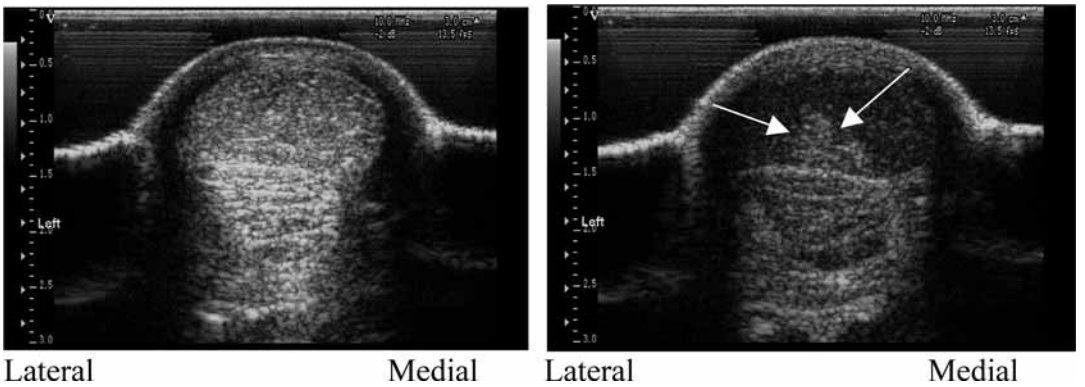

Fig. 1. Transverse ultrasonographs from the mid-metacarpal region showing the use of the off-incidence artefact and its ability to identify areas of poorly organized tissue post-healing. (Left) Normal on-incidence view. (Right) Transducer tilted by ~10°. Arrows show the retained echogenicity in the poorly organized scar tissue when the transducer is tilted.

ment to the medial and lateral aspects of the limb. Because the branches cannot be adequately examined from the palmar/plantar aspect of the limb, these are evaluated with the transducer placed directly over the branches on the medial and lateral aspects of the limb.

Careful preparation of the area is essential if good diagnostic images are to be obtained. After clipping, the area should be cleaned. Ideally, a surgical scrub should initially be used followed by surgical spirit, which degreases the skin and removes the bubbles created by the surgical scrub. Any excess is wiped from the limb, and then, high-viscosity contact gel is rubbed well into the skin. While scanning, the horse should be standing square so that both limbs are evenly loaded. Sedation may be necessary, although usually low doses of α-2 agonists (detomidine or romifidine) are used to minimize swaying. Both limbs should be examined, because many cases of strain-induced tendon injury have bilateral components. The contralateral limb can also serve as a comparison to help differentiate lesions from normal anatomical variants, which are usually bilaterally symmetrical.

There is no standardized technique, but a system of seven levels or zones is recommended; each has characteristic anatomical features.[1,2] The palmar/plantar pastern region is also divided into 3–5 levels or zones. The distal two zones correspond to the more distal position that can sometimes be achieved with a small footprint transducer; however, a more distal examination can be achieved with caudal limb position that hyperextends the distal interphalangeal joint. At least one longitudinal level is usually achievable with a linear transducer depending on the relative size of transducer and pastern. Easier access can be achieved by raising the foot on a block. Because a number of structures pass obliquely across the first phalanx, oblique 45° views should be used to perform a complete examination.

4. Principles of Interpretation—Ultrasonographic Pathology of Tendons and Ligaments

1. Echogenicity

For tendon injuries in general, hypoechoic change suggests an acute injury, whereas chronic pathology is characterized by a heterogeneous pattern of variable amounts of hypoechogenicity and hyperechogenicity. In chronic DDFT injuries (usually within the confines of the digital sheath), mineralization can frequently be found. Off-incidence transducer orientation can help to define areas of disorganized scar tissue in chronic injury, because it retains its echogenicity at greater transducer angles than normal tendon (Fig. 1).

2. Size

The SDFT cross-sectional area (CSA) is one of the most sensitive harbingers of impending reinjury because of excessive exercise during rehabilitation. There is large interindividual variation in CSA in normal horses. A recent study of a large number (n = 148) of National Hunt Thoroughbreds in the United Kingdom gave 80–130 mm^2 as the normal range for the mid-metacarpal region of the SDFT.[3] A >20% difference between limbs is considered a significant enlargement, although this may not be the case if both limbs are affected. When summing separately, the percentage of tendon damaged in the CSAs of the SDFT and the lesion from all seven levels is split into three levels: 0–15% damage is considered a mild injury, 15–25% damage is a moderate injury, and >25% damage is a severe injury. Sequential CSA measurements provide a more sensitive indicator of exercise to tendon healing mismatch during the rehabilitation phase. If the CSA at any level increases by >10%, it is advisable to maintain or lower the exercise level respectively.

The CSA on the other tendons and ligaments of the distal limb can also be used in this way. However, the CSA measurement of the proximal and

body regions of the SL is not possible, because the ultrasound "window" is narrower than the width of the ligament.

3. Pattern

In the longitudinal view, the tendon appears as a series of striations that relate to the linearity of the collagen fibers. Because tendon function relies heavily on this arrangement, the fiber alignment is important in assessing the current and, to some extent, the future functionality of healing tendon. The fiber alignment score (FAS) gives a semi-objective assessment between 0 (normal) and 3 (no striations visible).

4. Shape

Alterations in shape will occur with almost any tendon or ligament injury, but it can be an important indicator of subtle tendon pathology when the CSA is within the normal range. In addition, both percutaneous trauma, which tends to cause focal damage to the palmar surface of the SDFT, and focal adhesions in the tendon sheath can also distort the tendon shape.

5. Position

The SDFT becomes medially displaced with severe superficial digital flexor tendinopathy because of lengthening of the tendon. Adhesions can also alter the position of a tendon within tendon sheaths. In the case of the SDFT, complete transection of one branch in the pastern region results in a shift in position toward the side of the intact branch proximally (Fig. 2).

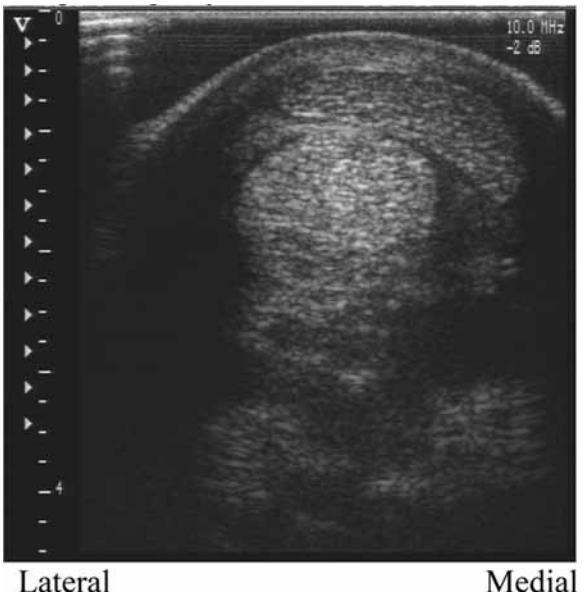

Fig. 2. Transverse ultrasonograph from the distal metatarsal region in a horse suffering a pastern laceration that had completely transacted the lateral branch of the SDFT. Note the altered medial position of the SDFT proximal to the metatarsophalangeal joint.

6. Margination

Within tendon sheaths, individual adhesions can sometimes be visualized when surrounded by fluid (normal mesotenon/synovial plicae). Poor tendon border definition has been suggested to be a sign of adhesions, but it can lead to their overestimation. Optimally, it should be determined by tenoscopy. Real-time imaging while the limb is flexed and extended will allow the ultrasonographer to assess the degree of the movement of the tendons and ligaments relative to one another and therefore, identify adhesion between adjacent structures.

Longitudinal tears in the DDFT within the digital sheath, easily observed tenoscopically, are often poorly discernible ultrasonographically. Greater sensitivity in detecting these tears can be made by using an oblique transducer position to assess the lateral and medial borders (Fig. 3). In contrast, some central defects may extend to the surface of the tendon without penetrating the epitenon and thus, may not be visible tenoscopically.

7. Vascularity

The blood flow within healing digital flexor tendons can be assessed using Doppler with the limb raised (Fig. 4). Normal digital flexor tendons usually have minimal discernible blood flow, whereas a pronounced vascular pattern is usually visible after injury. Hypervascularity is normal in the healing process but should subside as healing progresses.

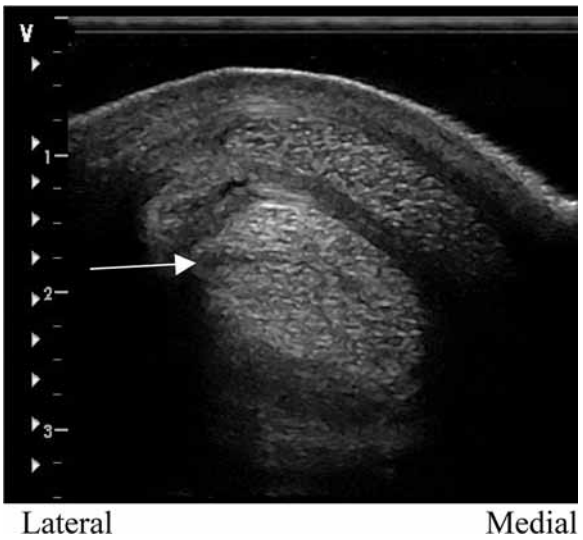

Fig. 3. Oblique transverse ultrasonograph from the palmarolateral aspect of the limb immediately proximal to the metacarpophalangeal joint showing a tear in the lateral margin of the DDFT. (Arrow) These are not always visible ultrasonographically. Note the echogenic material to the lateral side of the tendon that is a non-specific sign of such tears. This material can be torn tendon fibers or thicken synovial plicae, which can also be the site of fibrous mass formation is chronic cases.

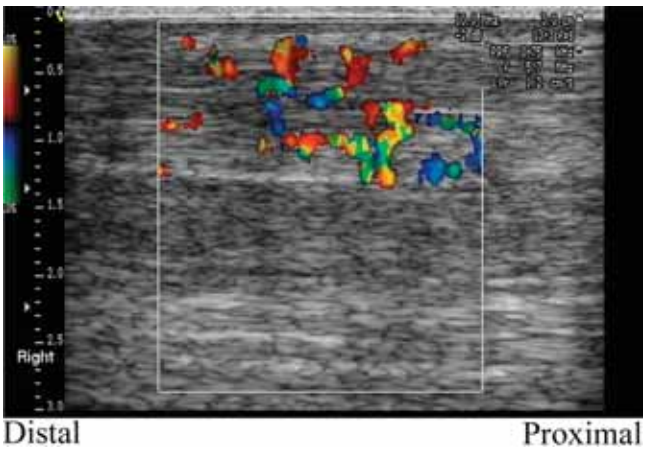

Fig. 4. Longitudinal ultrasonograph from the mid-metacarpal region from a horse with a damaged SDFT that showed increased vascularity with color-flow Doppler in a non–weight-bearing limb.

This technique is particularly useful for identifying exacerbations during the healing phase.

5. Ultrasonographic Appearance of the Metacarpal Region and Pastern Regions

SDFT

Proximally, the tendon lies within the carpal sheath as a semi-circular structure that is palmaromedial to the DDFT (Figs. 5 and 6). As the tendon runs distally, it reduces in the CSA and adopts a rounded medial contour and sharper lateral border. In the distal metacarpal region, it thins in a dorsopalmar direction and extends a ring of tissue around the DDFT (the manica flexoria). Tearing of the attachment of this structure to the SDFT can cause lameness (especially in hindlimbs), although diagnosing this ultrasonographically is difficult.

Distal to the fetlock, the SDFT continues as a thin structure that then divides into two branches in the mid-pastern region. Before its division, the distal "manica," another ring of the SDFT surrounding the DDFT, is usually visible deep to the DDFT. It is a useful landmark, but contrary to its more proximal sister, it is rarely significantly injured. The two SDFT branches run abaxially to insert through the thick fibrocartilagenous middle scutum onto the proximopalmar aspect of the middle phalanx. These branches are best observed ultrasonographically as comma-shaped structures with the transducer on the palmarolateral and palmaromedial aspects.

DDFT

In the proximal forelimb, the DDFT lies dorsolateral to the SDFT. As the tendon runs distally, it becomes more circular and also reduces in the CSA. In the mid-metacarpal level, the ALDDFT joins the DDFT on its dorsal surface and becomes enclosed in the one paratenon. However, the fibers of the ALDDFT can be identified, separated from the DDFT by a hypoechoic curved line, for an appreciable distance distally. In the distal metacarpal region, the DDFT increases in the CSA and becomes oval in shape at the level of the MCP joint. In the hindlimb, the dorsal surface of the DDFT usually has a well-circumscribed hypoechoic region within it in the proximal limit of the digital sheath that is normal.

Within the pastern region, the DDFT will frequently contain a dorsal hypoechoic region immediately distal to the ergot caused by off-incidence artefact from the change direction in the DDFT. As the DDFT runs distally, it adopts a bilobed appearance.

The DDFT can be examined further distally, but this requires a small footprint (e.g., curvilinear) probe that can be placed in the longitudinal plane between the bulbs of the heel. This allows identification of the DDFT distally to the level of the proximal border of the navicular bone, but it is off incidence. The DDFT overlying the navicular bone and inserting onto the solar surface of the distal phalanx can be seen when scanning through the frog; however, only the central portions of the tendon are visible.

ALDDFT

This ligament arises from the palmar carpal ligaments where it lies on the dorsal surface of the carpal sheath. It runs from a deep position proximally to a more superficial position distally where it joins onto the dorsal surface of the DDFT in the mid-metacarpal region. Proximally, it is a discrete structure that is separate from the other structures on the palmar aspect of the limb with a prominent longitudinal striated pattern. It runs in a slightly oblique angle compared with the flexor tendons, and its on-incidence echogenicity tends to be at a slightly different probe orientation to the flexor tendons. Thus, the flexor tendons or the ALDDFT can appear brighter than the other depending on probe orientation. As it runs distally, it starts to conform to the dorsal surface of the DDFT. The majority of the ligament is laterally positioned so that the transducer has to be moved to a palmarolateral position to view the entire ligament.

SL

At its origin, the echogenicity can be very variable, and it can include central hypoechoic regions. These normal variants are caused by areas of looser connective tissue within the ligament that contain fat and vascular elements. They are usually bilaterally symmetrical, but the presence of hypoechoic areas in this region should only be interpreted in the light of clinical examination and diagnostic analgesia. The dorsal border of the ligament is usually distinct and separated from the underlying palmar aspect of the metacarpus by a small anechoic gap. This hypoechoic area

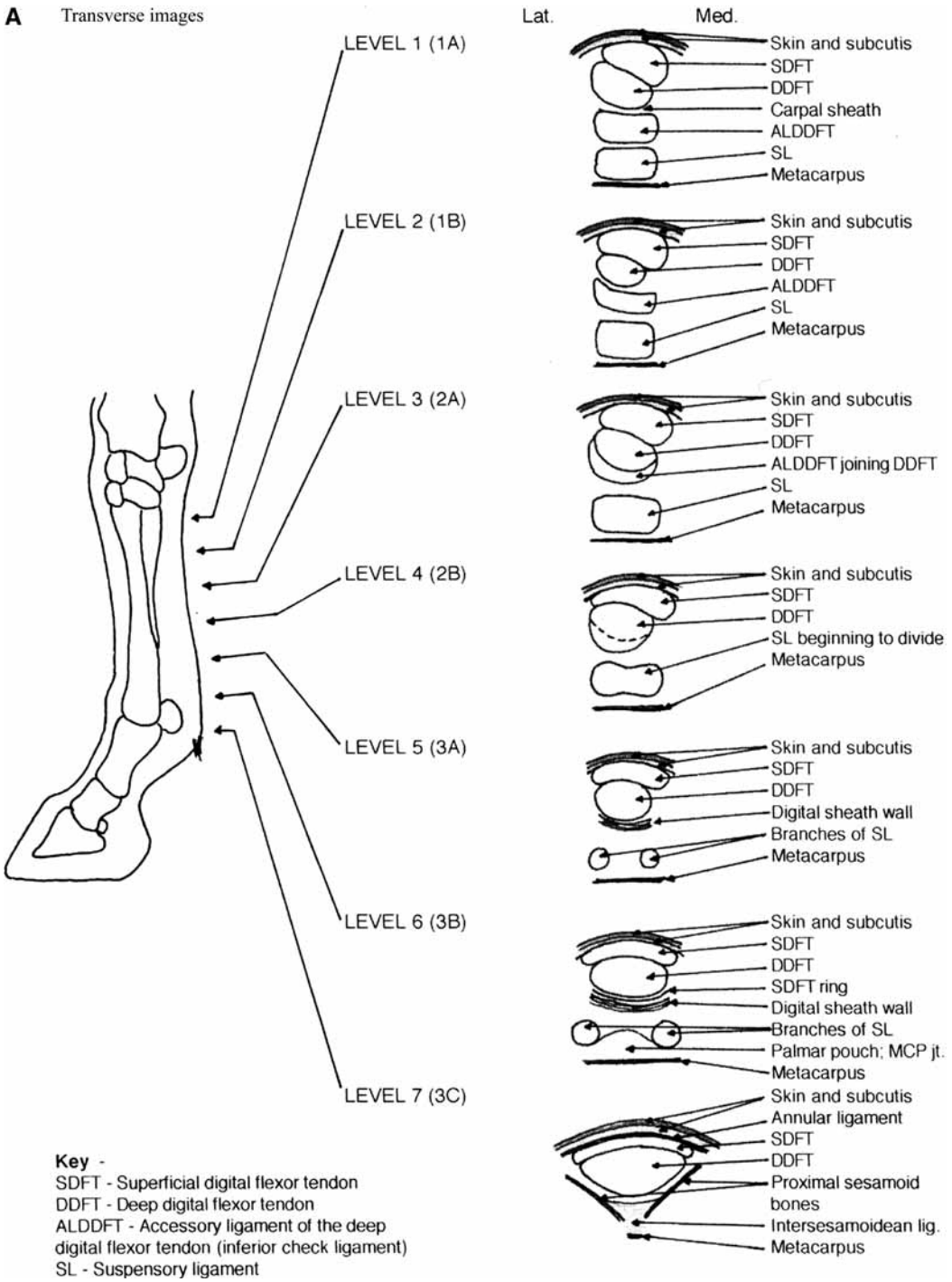

Fig. 5. Diagram representing the ultrasonographic anatomy of the metacarpal region. (A) Transverse images. (B) Longitudinal images. (From Smith RKW, Webbon PM. Diagnostic imaging—musculoskeletal ultrasonography. In: Hodgson DR, Rose R, eds. *The athletic horse*. 1992.)

becomes obliterated when the ligament is enlarged through pathology.

Both proximal and body regions of the forelimb SL are rectangular in shape in transverse images, but this only represents the middle one-third of the ligament because of the size of the ultrasonographic window. The medial and lateral borders can only be visualized by tilting the transducer onto the palmaromedial and palmarolateral aspects proximally and then positioning the transducer directly over the medial and lateral borders in the mid-metacarpal region where the splint bones are smaller. Because of the variable presence of muscle within the proximal and body (but not the branches) of the SL,

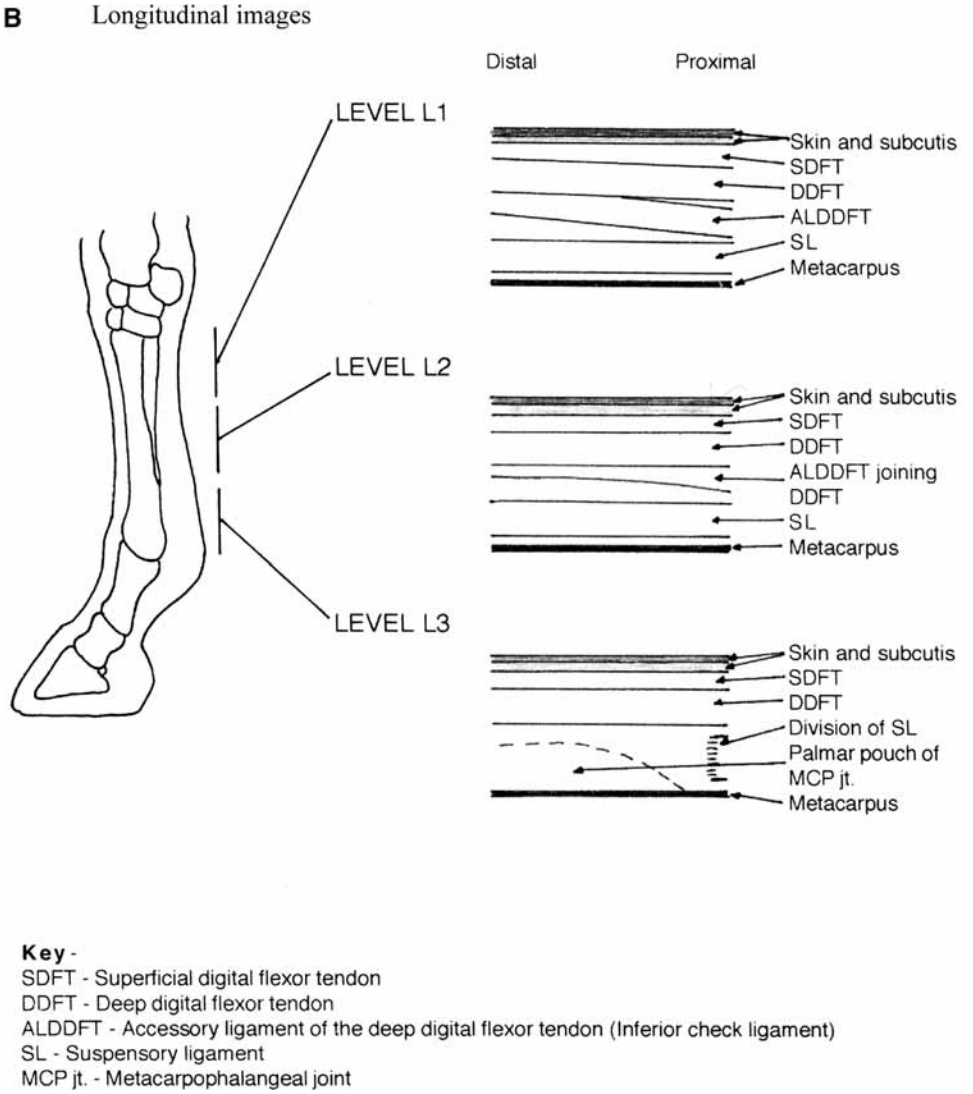

Fig. 5. (continued)

the longitudinal striated pattern of the SL is more coarse than seen in the flexor tendons.

The proximal SL in the hindlimb is more triangular in shape, and it is closely associated with the large head of the fourth metatarsal (lateral splint) bone and the smaller head of the second metatarsal (medial splint) bone. This area is difficult to evaluate and can be improved by one of the following two actions:

1. Move the transducer to the medial aspect of the limb. The ultrasonographic window is larger in this location because of the small head of the second metatarsal bone. A more complete evaluation of the proximal SL can be obtained in this location; however, edge refraction artefacts from the prominent blood vessels superficially in this region can induce shadows within the proximal SL.
2. Use a curvilinear transducer or "compounding," which provides a wider view of the deeper areas.

In longitudinal views, the proximal SL has a striated pattern, and the majority of the ligament is attached to the proximal palmar/plantar metacarpus/metatarsus. The most superficial portion of the ligament, however, continues and inserts more proximally.

In the distal one-third of the metacarpal region, the SL adopts a dumbbell shape in transverse images as it divides into two separate branches. Because of edge refraction shadowing from the borders of the flexor tendons, the branches cannot be visualized adequately from the palmar aspect of the limb, and therefore, the transducer needs to be moved so that it lies directly over the medial and lateral SL branches. These branches increase in the CSA in a proximodistal direction and are a teardrop shape. They lie immediately adjacent to the skin. Any pathology in these branches results in fibrosis between the branch and the skin, which effectively "moves" the branch away from the skin.

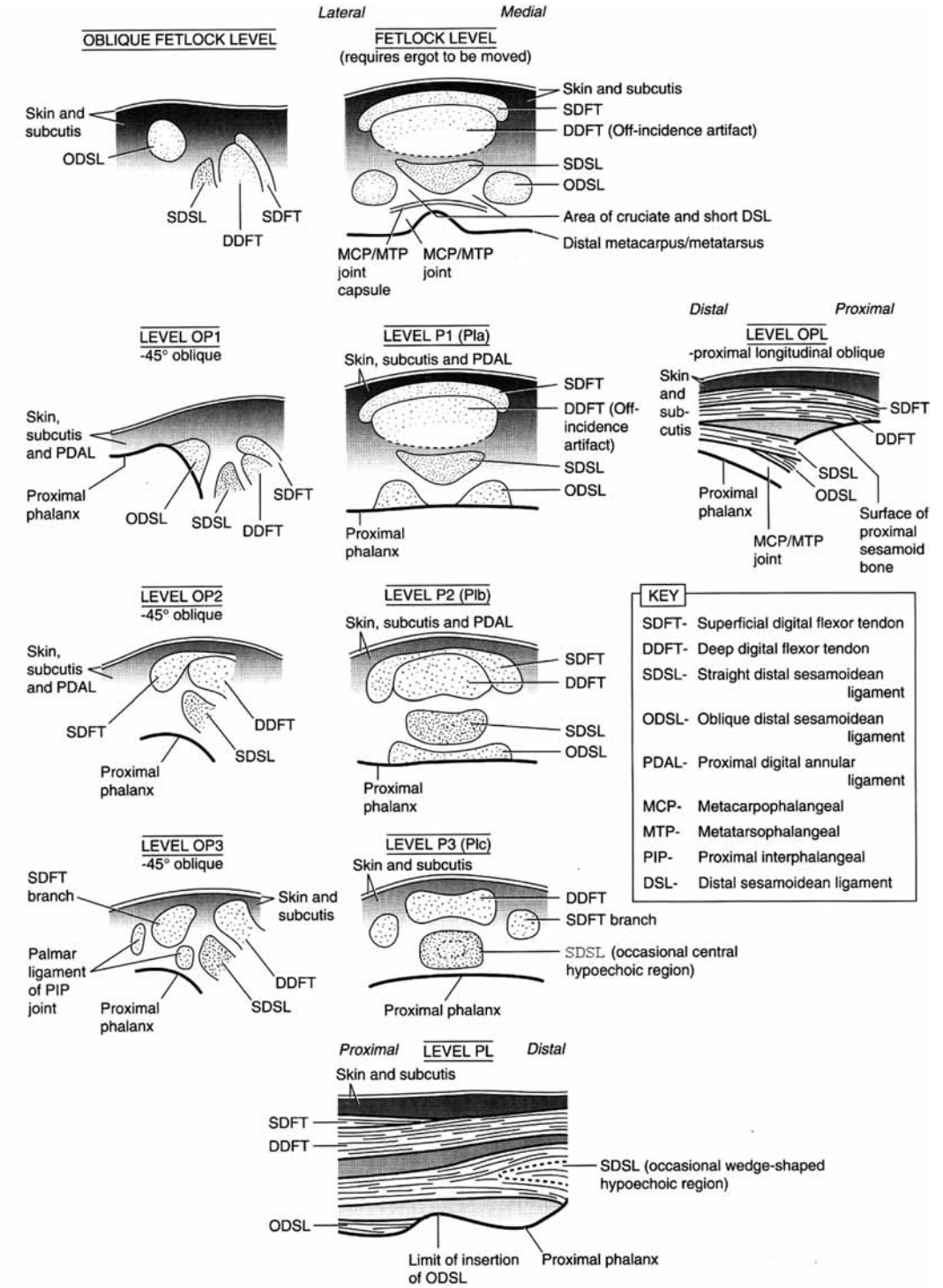

Fig. 6. Diagrammatic representation of ultrasonographic anatomy of the pastern region. (From Smith RKW, Webbon PM. Soft tissue injuries of the pastern. In: Robinson, NE, ed. *Current therapy in equine medicine*, 4th ed. Philadelphia: W.B. Saunders Co., 1997;61–69.)

Corresponding longitudinal images should also be obtained starting with the most distal of these longitudinal images where the attachment site of the SL branch onto the abaxial surface of the proximal sesamoid bone appears as an S-shaped surface; this has been termed, descriptively, the "ski-jump view."

The branches show similar fiber alignment to flexor tendons at this level.

Digital Sheath

The digital sheath extends from the distal metacarpal/metatarsal region to the foot on the palmar/plantar aspect of the limb. Therefore, abnormalities of this structure should include evaluation of this entire region. The digital sheath is commonly associated with pathology in the pastern region, although its involvement is more frequently secondary. In normal horses, the digital sheath contains only small amounts of synovial fluid, and its intrathecal architecture is often obscure. However, with effusion, more structures become visible. Outpouchings of the digital sheath can be seen proximally abaxial to the flexor tendons, immediately distal to the proximal sesamoid bones abaxially, and in the distal pastern region in the midline superficial to the DDFT. This is the best site to aspirate synovial fluid from the sheath.

In the distal metacarpal region within the proximal pouch of the digital sheath, abaxial synovial plicae connect the DDFT to the digital sheath wall both medially and laterally. Although not normally visible in the non-distended sheath, they are easily identified with the improved contrast associated with sheath distension. The plicae should not be confused with adhesions, but they are useful structures with which to assess the status of the synovial membrane.

In the distal pastern region, a normal thin mesotenon is sometimes visible in the midline between the DDFT and the digital sheath.

Palmar/Plantar Annular Ligament of the Fetlock

Identification of the palmar/plantar annular ligament of the fetlock (PAL) in normal horses is difficult because of its size (1–2 mm in thickness).[4–6] However, moving the probe medially or laterally away from the midline (where the annular ligament is joined to the SDFT by the vinculum) will improve definition of the ligament by the relatively hypoechogenic synovial lining (± synovial fluid) between it and the SDFT. If it still cannot be identified with confidence, the probe should be moved further medially or laterally to visualize its attachment to the very palmar/plantar border of the proximal sesamoid bones.

Some veterinarians prefer to assess the PAL by measuring the distance between the palmar/plantar surface of the SDFT and the skin surface, although this distance will include the skin, SC tissues, PAL, and synovial membrane. All of these can be affected to a variable degree in the condition of annular ligament syndrome (see below). A normal measurement of 3.6 ± 0.7 mm has been quoted; therefore, anything >5 mm should be considered significant.[4]

Digital Annular Ligaments

The digital annular ligaments (proximal and distal) cannot be easily visualized in the normal horse, because they are usually <1 mm in thickness. However, they can be seen when enlarged. They can be identified proximal to the distal out-pouching of the digital sheath, especially medially and laterally where they are more discrete structures grossly.

Distal Sesamoidean Ligaments

Both the oblique distal sesamoidean ligament (ODSL) and straight distal sesamoidean ligament (SDSL) can be identified ultrasonographically. The SDSLs are the most echogenic structures within this region and are often more easily assessed in the longitudinal images. The ODSLs require oblique views for adequate imaging. The short and cruciate distal sesamoidean ligaments (DSLs) cannot be distinguished but can sometimes be identified adjacent to the joint capsule in oblique views of the palmar/plantar aspect of the fetlock joint.

The insertion of the SDSLs onto the middle scutum on the palmar/plantar aspect of the proximal interphalangeal (PIP) joint frequently contains a hypoechoic "core" or "sandwich" in the transverse views (P3 only) and a hypoechoic "wedge" with its apex directly proximally in the longitudinal view. The hypoechoic region does not usually extend farther proximally than the distal limit of insertion of the ODSL. These are normal anatomical variations and should not be mistaken for pathology.

Differences in the Hindlimb

The ultrasonographic anatomy of the metatarsal region is similar to the metacarpal region, but there are a few differences:

- The SDFT is positioned laterally and the DDFT is positioned medially in the proximal metatarsal region.
- The subtarsal check ligament (ALDDFT) is a very thin structure lying on the dorsal surface of the distal tarsal sheath wall.
- The medial head of the DDFT, in its own tendon sheath, joins the DDFT on its medial border in the very proximal metatarsal region.
- The SL arises as a triangular structure adjacent to the third and fourth metatarsal bones (the latter is particularly prominent proximally).
- Proximal to the tarsometatarsal joint, three structures are visualized—the SDFT superficially, the DDFT deep to the SDFT and medially positioned, and the plantar ligament deep to the SDFT and laterally positioned.

6. Ultrasonographic Pathology

Superficial Digital Flexor Tendinopathy

A common manifestation of acute injury to this tendon is a concentric hypoechoic/anechoic lesion visible in the center of the tendon (thus, the usual term "core lesion"), usually centered in the mid-metacarpal region. It is accompanied by enlargement and SC edema in the acute stage. Lesions can also be localized eccentrically to the borders of the tendon—medially, laterally, dorsally, or palmarly. Often, dorsal lesions are thought to be associated with more lameness, presumably because of the direct pressure exerted by the DDFT onto the lesion under weight-bearing load.

In very subtle cases, often the only finding can be enlargement and/or change in shape of the tendon. This can be accompanied by peritendinous edema, which is not specific for tendonitis and can also result from local trauma. Providing that there is no evidence of tendon injury and the edema disappears, work can be recommenced after only a short period of rest. However, persistent edema suggests the presence of tendonitis.

Not all lesions involved local abnormalities, and another common manifestation is a generalized hypoechogenic tendon. This may represent either a tendon that is healing in which the core lesion has disappeared or, if the injury is recent, more diffuse damage to the tendon and/or intratendinous edema.

Injury can also occur to the SDFT in the fetlock (low bow) and pastern regions where it is associated with variable amounts of digital sheath effusion. Damage to the SDFT in the region of the fetlock canal appears ultrasonographically as a hypoechoic tendon with minimal enlargement because of the constraints of the palmar annular ligament. As a result, these injuries are often associated with secondary thickening of the palmar annular ligament. Injury to the branches of the SDFT is best identified by enlargement and hypoechogenicity of individual branches that is usually observed with the transducer positioned palmarolaterally or palmaromedially. There is usually secondary SC fibrosis with these injuries in contrast with those affecting the SDFT more proximally. If the injury is localized to the region of the MCP joint or distally, then there may be evidence of previous injury to the mid-metacarpal region.

Complete rupture of the SDFT is the most severe extreme of an overstrain injury, and it often results in an almost totally anechoic region of the SDFT surrounded by a thin echogenic line called the paratenon; this usually remains intact unless the injury has been caused by percutaneous trauma. Evidence of damage will also be apparent proximal and distal to the rupture. If the tendon ends have retracted, the outline of the paratenon at the site of the rupture may not be particularly enlarged but bunched up, retracted fibers will be identifiable proximal and distal to the rupture site. The SDFT also becomes medially displaced because of lengthening of the tendon.

Semi-Objective Assessment of Injury to the SDFT

Objective measurements potentially allow a better determination of prognosis and assessment of healing. The following measurements have been suggested: (1) the CSA (transverse image), (2) the percentage of damaged tendon (transverse image) for focal lesions, (3) the type of lesion, and (4) the FAS (longitudinal image).

1. There is a large interindividual variation in the CSA in normal horses—80–130 mm^2 for Thoroughbreds.[3,7] A >20% difference between limbs is considered a significant enlargement, although this may not be the case if both limbs are affected.[7]
2. The CSAs for both the size of the focal lesion and the total tendon CSA at each individual level can be summed for all seven levels or zones to give an approximation of the "volume" of the lesion over the volume of the tendon. This has been used to give what is thought to be the optimal assessment of severity: 0–15% of the tendon affected is a mild injury, 16–25% of the tendon affected is a moderate injury, and >25% of the tendon affected is a severe injury.[8] An alternative method is to consider the maximum injury zone only. A mild injury involves <10% of the CSA, a moderate injury involves 10–40% of the CSA, and a severe injury involves >40% of the CSA. However, this obviously does not take into account the length of the lesion.
3. There are four types of lesions or degrees of echogenicity. Type 1 is a hypoechoic lesion with more white than black. Type 2 is a hypoechoic lesion with the same amounts of white and black. Type 3 is a hypoechoic lesion with more black than white. Type 4 is an anechoic lesion with all black and no white.
4. The FAS (longitudinal image) is assessed subjectively on a scale from 0 (76%–100% parallel fibers; normal) to 3 (0–25% of parallel fibers).

Assessment of Healing

All tendon injuries should ideally be monitored ultrasonographically at 3-mo intervals or before and after a change in the exercise level. At each examination, the following indicates good progress:

1. A stable or decreasing CSA. Sequential CSA measurements provide the most sensitive indicator of exercise to tendon healing mismatch during the rehabilitation phase. If the CSA at any level increases by >10%, it is advisable to maintain or lower the exercise level.
2. An increase in the lesion echogenicity and a homogeneous texture.

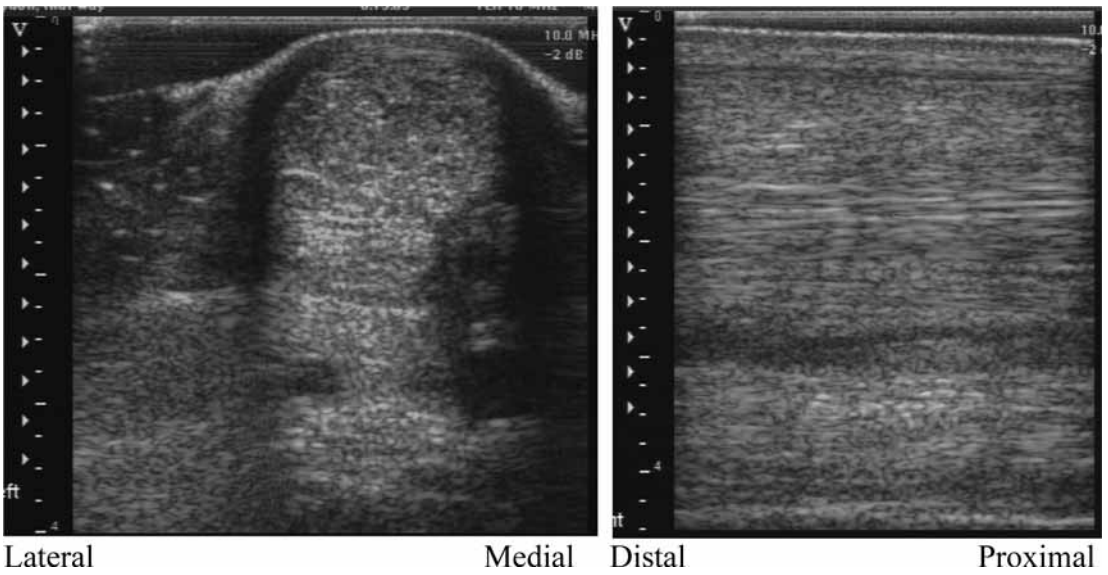

Fig. 7. (Left) Tranverse and (right) longitudinal ultrasonographs taken from the proximal metacarpal region of a horse with chronic superficial digital flexor tendinopathy. Note the enlarged SDFT with heterogeneous echogenicity and a poor longitudinal striated pattern. This is similar to the appearance of the tendon in the transverse image, which suggests the absence of normally aligned collagen fibers.

3. An improvement in the striated pattern seen longitudinally (fiber alignment).
4. An absence of peritendinous fibrosis and adhesions.[8]

More recently, the blood flow within healing digital flexor tendons can be assessed with the limb raised using Doppler (Fig. 4).[9] Normal digital flexor tendons usually have minimal discernible blood flow, whereas, after injury, a pronounced vascular pattern is usually visible. Hypervascularity is normal in the healing process. However, it should subside as healing progresses (normally between 3 and 6 mo after injury), and its reappearance can be an indication of reinjury.

Horses suffering from tendonitis are constantly at risk of reinjury. Healing, determined histologically, takes at least 15–18 mo.[10] The mean interval between injury and return to training in racehorses is dependent on the severity of the initial injury and varies between 9 and 18 mo.[10] Sports horses may be able to return to full work in a shorter time, but even the mildest ultrasonographically detectable injuries should have at least 6 mo to heal. Occasionally, horses are returned to full work before full resolution of the ultrasonographic lesion; however, this success may be caused by the horse being capable of sustaining work despite the presence of a tendon injury.

Chronic Tendinopathy

The ultrasound characteristics of chronic tendinopathy are more variable and can be subtle. The tendon is often enlarged, but its echogenicity varies from hypoechogenic through normoechogenic to hyperechogenic if the injury is severe and substantial fibrosis has occurred. The intratendinous pattern is usually more coarse and lacks striations in the longitudinal images (Fig. 7). In some cases, the outline of the original core lesion can still be seen. Mineralization may occur, which causes acoustic shadowing. However, if the calcification is florid, previous intratendinous injection of depot corticosteroids should be suspected. Off-incidence transducer orientation can help to define areas of disorganized scar tissue in chronic injury, because it retains its echogenicity at greater transducer angles than normal tendon (Fig. 1).

Local Trauma

Overstrain injuries need to be distinguished from local trauma caused by a bandage (so-called "bandage bow") or percutaneous trauma from, for example, a hindlimb. The effects of local trauma can vary from localized peritendinous edema with no evidence of intratendinous damage to localized hypoechoic/anechoic lesions on the palmar surface of the tendon (Fig. 8) to partial or complete transection. Local traumatic injuries do not extend far proximodistally. However, partial lacerations can be associated with longitudinal splits in the tendon that extend proximally or distally; these result from altered shear stresses. Partial lacerations can also be easily missed if the examination is restricted to the site of the wound, because they often occur when the tendon is fully loaded. Therefore, the site of injury moves more proximally in the resting or reduced weight-bearing limb. Ultrasound is, therefore, very useful to identify these sites of injuries not visible through the wound. Complete transection

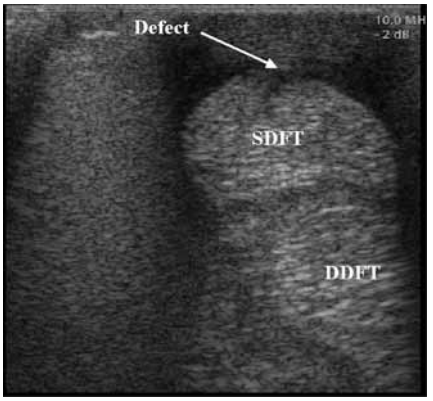

Fig. 8. Transverse ultrasonograph from the proximal metatarsal region in a horse that has suffered percutaneous trauma to the SDFT. Note the plantar surface defect (labeled).

of one branch of the SDFT in the pastern region results in a shift in position of the SDFT toward the side of the intact branch more proximally.

Sepsis after a penetrating injury (or occasionally, hematogenous spread) of the SDFT is rare. It usually gives an anechoic lesion, often with a communicating tract to the periphery of the tendon. Aspiration of the lesion will yield a sample containing large numbers of degenerate neutrophils. These lesions do not usually cause gross enlargement of the affected tendon and change rapidly in time compared with the core lesion in a tendon strain. If the lesion is present within a tendon sheath, there will usually be an accompanying septic tenosynovitis.

Manica Flexoria Tears

This is a common cause of digital sheath tenosynovitis, especially in hindlimbs.[11] Ultrasonographic diagnosis is difficult, but an altered position of the manica flexoria seen in a longitudinal scan in the midline immediately proximal to the metacarpo/metatarsophalangeal joint is probably the best indicator (Fig. 9). Tenoscopic assessment provides the definitive diagnosis.

Deep Digital Flexor Tendinopathy

DDFT injuries are extremely rare in the metacarpal region, but they do occur within the confines of the digital sheath. Of the strain-induced DDFT injuries, there are two forms—the intratendinous injury and surface tears.

Intratendinous Injury

Intratendinous injuries are frequently centered at the level of the MCP joint. They result from a sudden overextension of the distal interphalangeal joint when the MCP joint is fully extended and the limb is weight bearing. These injuries are frequently associated with considerable disruption of the tendon resulting in marked and persistent lameness. There is usually concurrent tenosynovitis and as with most soft tissue injuries in the phalangeal region, SC fibrosis. Other lesions are manifest by focal hypoechogenic lesions proximal[12] or distal to the MCP joint. Many central defects may extend to the surface of the tendon without penetrating the epitenon and therefore, may not be visible tenoscopically (Fig. 10).

Because of the location of the injuries within the digital sheath, healing is, at best, problematic. In the chronic stage, the lesions often persist as hypoechoic lesions with or without areas of calcification. Lameness usually persists, arising from tenalgia and/or adhesion formation within the sheath. Such adhesions can distort the tendon shape.

Border Tears

Damage to the surface of the DDFT can occur as a variant of overextension injury to the tendon.[13] This frequently occurs at the lateral and less commonly, medial borders of the DDFT in the region of the MCP joint. It occurs most commonly in the

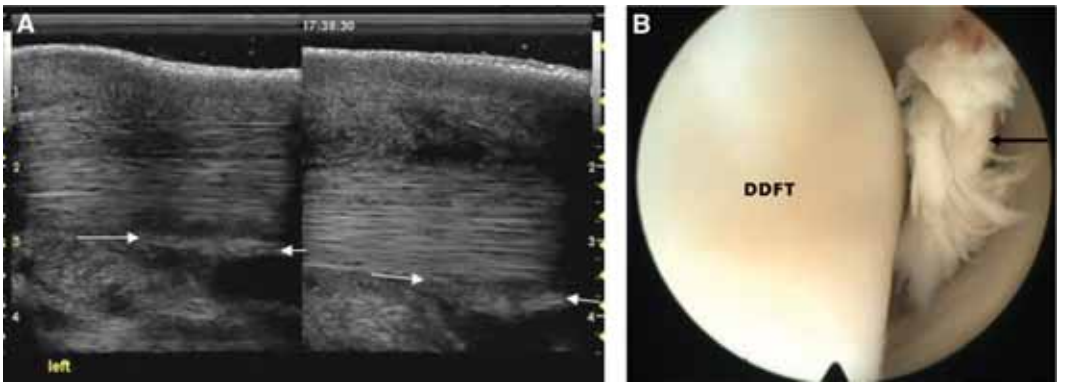

Fig. 9. The best method of diagnosing a manica flexoria tear ultrasonographically involves the identification of instability of the manica in midline longitudinal views in the distal metatarsal region. (A) The normal contralateral limb is on the left, and the torn manica flexoria is on the right. Note the wavy form to the manica (arrows). (B) Tenoscopic appearance. The arrow indicates torn manica.

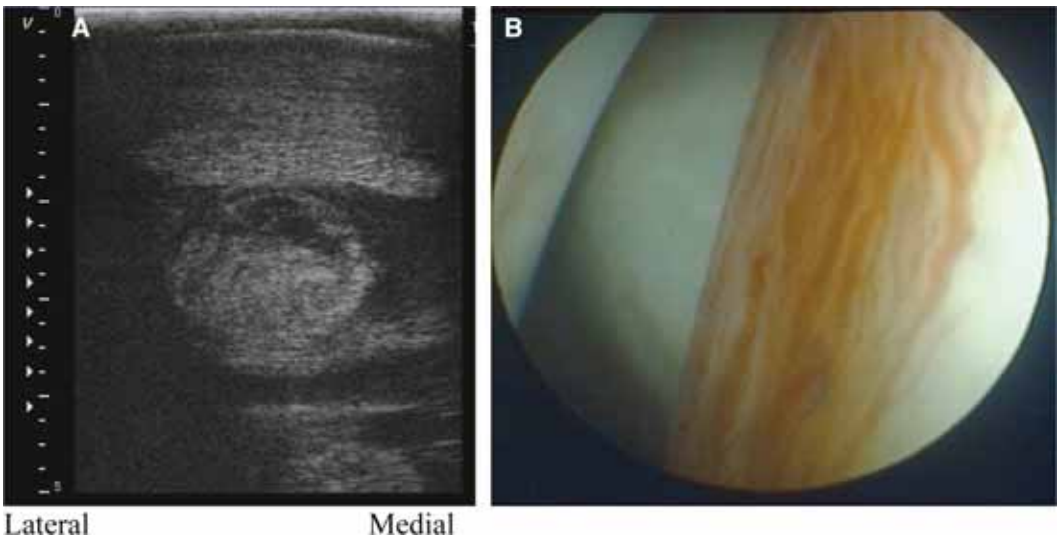

Fig. 10. The image on the left is a transverse ultrasonograph from the region of the proximal digital sheath in a horse suffering from deep digital flexor tendinopathy. Note the hypoechoic region on the palmar surface of the DDFT. Tenoscopic examination of this case (right) proved that the lesion did not communicate with the digital sheath, which has important consequences for management and healing.

forelimbs, presumably because of excessive forces during overextension that compress the tendon and cause a pressure-induced rupture.[11] Because of their intrasynovial location that is surrounded by synovial fluid, healing does not occur. These lesions often persist, being responsible for persistent digital sheath tenosynovitis and lameness.

Confident diagnosis of these tears using ultrasonography is difficult. Greater sensitivity in their detection can be made by using an oblique transducer positioned to assess the lateral and medial borders (Fig. 3). However, a negative finding on ultrasound does not rule out the presence of a tear. Tenoscopy is recommended to identify occult tears and should certainly be considered in those cases of tenosynovitis that have failed to respond or recurred after intrathecal medication.

Local Trauma

Local trauma to the palmar/plantar aspect of the pastern is common during overextension of the metacarpo/metatarsophalangeal joint at maximal exercise. Because of the close proximity to the skin, such injuries frequently damage the digital sheath and DDFT. Such combination injuries can result in digital sheath (and rarely, DDFT) sepsis if open, which gives rise to effusion and synovial thickening that is evident ultrasonographically. This synovial thickening also usually involves the epitenon surrounding the DDFT, which gives a "halo" appearance to the tendon. Such signs, although not pathognomic for sepsis, are strongly suggestive of it, and they should indicate synoviocentesis to confirm or refute the presence of sepsis. Local trauma will cause variably sized hypoechogenic lesions within the DDFT and enlargement, and it is often associated with adhesion formation between the damaged areas of the DDFT and sheath wall. Individual adhesions can sometimes be visualized ultrasonographically when surrounded by fluid (normal mesotenon/synovial plicae). Poor tendon border definition has been suggested as a sign of adhesions, but it can lead to overestimation of adhesions. When percutaneous trauma does not penetrate the skin, damage can still be induced in the underlying DDFT (blunt contusion), which may only become visible as a hypoechoic lesion over time. Therefore, if clinical signs persist, a repeat ultrasonographic examination is indicated after 2–4 wk.

7. Suspensory Ligament—Ultrasonographic Appearance and Pathology

Proximal Suspensory Desmitis

Proximal suspensory desmitis is also called high suspensory disease or proximal metacarpal syndrome. The ultrasonographic appearance of this injury has considerable overlap with the normal appearance. The presence of hypoechoic areas in the proximal SL is common in normal horses, and therefore, the significance of such findings must be interpreted in the light of clinical findings (swelling and pain on palpation) and diagnostic local analgesia. Those considered to be true lesions of SL desmitis will vary in time, and therefore, repeat examinations are useful to confirm their significance.

Ultrasonographic features of injury include enlargement of the SL, poor definition to the margins (especially dorsally), single or multiple poorly defined focal areas of hypoechoicity, diffuse hypoechoicity, and irregularity of the palmar surface of the proximal metacarpus/metatarsus, which is indicative of enthe-

siophytosis. In addition to the ultrasonographic abnormalities, radiographic changes, such as sclerosis and altered trabecular pattern at the origin of the SL, may also be present. They may occur with or without concurrent increased radionuclide uptake on gamma scintigraphy in the proximal metacarpal/metatarsal regions. Differential diagnoses include palmar cortical fractures, which usually have no abnormalities within the proximal SL and higher uptake on gamma scintigraphy, and avulsion fractures of the head of the SL, where abnormalities in the SL are often confined to an area immediately adjacent to the site of the avulsion fracture.

Desmitis of the Body of the SL

If this area is injured, there is usually generalized hypoechogenicity and enlargement to the ligament. In competition/sports horses, the injury often extends into the branches of the SL.

There is some controversy over the link between suspensory desmitis and splints. Some aggressive exostoses on the second or fourth metacarpal/metatarsal bones may impinge on the body of the SL and cause a localized suspensory desmitis, but this probably occurs in only the minority of cases. Many exostoses grow around rather than into the SL. Careful assessment by oblique positioning of the ultrasound transducer is necessary, because the ultrasound "window," when the transducer is placed on the palmar/plantar aspect, does not usually extend sufficiently abaxially to image these areas adjacent to the splint bones.

Desmitis of the SL Branches

This is the most common of the SL injuries in sports horses. In the forelimbs, biaxial desmitis has the highest incidence, whereas lateral branch desmitis is the most common manifestation in the hindlimbs. A core lesion or generalized involvement of the branch, together with enlargement, is seen ultrasonographically. The longitudinal image from the abaxial aspect gives an excellent assessment of the abaxial surface of the proximal sesamoid bones where any associated enthesiopathy is seen by steps in the S-shaped surface of the bone. The size of the SL branches should be compared with both contraaxial and contralateral branches at the same level, because the branches increase in size in a proximodistal direction. One of the most sensitive indicators of suspensory branch desmitis is periligamentar fibrosis, which is extremely common in this condition. It has the effect of "moving" the SL branch away from the skin (Fig. 11).

Clinical and radiographic examination of the metacarpo/metatarsophalangeal joint is also recommended in cases of SL desmitis. Concurrent pain and pathology in this joint is frequently present because of the nature of the injury (hyperextension). Furthermore, radiography will reveal bony pathology that is frequently associated with the SL body and branch desmitis, such as enthesiopathy of the proximal sesamoid bones ("sesamoiditis") and distal splint bone fractures.

Fig. 11. Transverse ultrasonograph taken from the lateral aspect of the forelimb of a horse suffering from suspensory branch desmitis. Note the collar of periligamentar fibrosis (arrows) that is characteristic of this condition.

8. Other Diagnostic Techniques for Diagnosing Tendon and Ligament Injuries

In the ultrasonographic descriptions of pathology outlined above, other imaging techniques have been mentioned including radiography (for the identification of mineralization and/or enthesiopathy in chronic disease) and the pool phase of gamma scintigraphy. More recently, the advent of magnetic resonance imaging (MRI)[14] and computed tomography (CT), including contrast-enhanced CT,[15] for horses has enabled us to identify pathology in those areas where ultrasonography is limited. This has been particularly true for the foot—most commonly for injuries of the DDFT (Fig. 12) and the collateral ligaments of the distal interphalangeal joint. However, it is also beginning to help us differentiate pathologies in other areas where ultrasonography has frequently not provided sufficient evidence of pathology, such as the proximal suspensory region.

Finally, although not available clinically as yet, it is hoped that the use of molecular markers, assayed in blood or synovial fluid (for intrasynovial tendon and ligament injuries), may allow us to diagnose and monitor tendon injuries. This would provide an objective assessment of the efficacy of different treatments. One such marker is cartilage oligomeric matrix protein (COMP), which has shown good differentiation of digital sheaths containing injured tendons (e.g., tendon tears that are poorly identified by other means other than tenoscopy) compared with those without tendon pathology.[16]

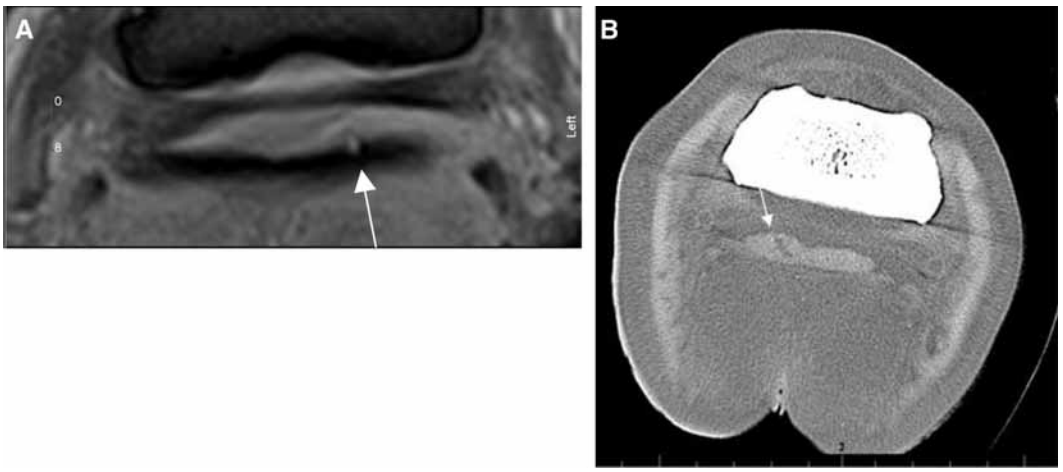

Fig. 12. (A) CT and (B) MRI images of DDFT tears (arrows) in the foot. (MRI image courtesy of Mr. Tim Mair, MRCVS.)

9. Treatment for Tendon and Ligament Injury (adapted from Davis and Smith[17])

Over the years, many treatment modalities have been tried, and most show equivocal or even deleterious effects on tendon healing. From our knowledge of the phases of tendon healing, the following summarizes those treatments that have at least a rationale for treating superficial digital flexor tendinopathy.

1. Physical Therapies

1. Cold, Pressure, and Support

In the acute inflammatory phase of tendon injury, cold therapy is an important aspect of treatment, because it is both anti-inflammatory and analgesic. This is because of its ability to cause vasoconstriction, decrease enzymatic activity, reduce the formation of inflammatory mediators, and slow down nerve conduction.[18] It should be applied several times a day. Cold hydrotherapy seems to be superior to the use of ice packs because of the increased contact time and evaporation.[19] It is also less likely to cause adverse effects such as superficial tissue damage because of local freezing. Prolonged exposure to cold temperatures can also cause a reflex vasodilatation that will potentially accentuate tissue swelling and edema. For this reason, it is recommended not to apply cold therapy for periods >30 min. One highly effective way of providing cold hydrotherapy is the use of equine spas, which are currently gaining popularity. They provide both cold and compression using hypertonic saline at 5–9°.

Cold can be combined with pressure applied to the affected limb. This will reduce inflammation and edema formation by increasing interstitial hydrostatic pressure. A modified Robert Jones bandage is suitable in most cases of acute tendon and ligament injury of the metacarpal/metatarsal region and pastern.

In acute stages, rest provided the easiest way of limiting loading on the damaged soft tissue. In severe injuries where there is hyperextension of the MCP joint, a palmar/plantar splint or cast may be applied to the bandaged limb to provide MCP joint support. A palmar splint can be fashioned from two rolls of 7.5-cm (5-in) casting tape. One roll is layered on top of itself over a length that matches the length of the limb from the carpus to the bulbs of the foot. This is placed on the palmar aspect of 2.5-cm thickness support bandage on the contralateral limb, which is used to provide the optimal degree of extension at the MCP joint. A second roll is wrapped around the palmar splint and bandage and left to set. The palmar splint is then cut away from the bandage using a cast saw, and it is applied to the palmar aspect of the bandaged affected limb. Research has shown this to be effective at reducing the extension of the MCP joint, and thus, it loads the palmar soft tissue structures at normal weight-bearing loads.[20] A similar effect can be achieved more easily with the specially designed boot, although this has yet to be available commercially.[20] A full distal limb cast may be used as an alternative in the most severe cases, such as SL rupture, when all MCP joint support has been lost.

2. Extracorporeal Shock Wave Therapy

Extracorporeal shock wave therapy (ESWT) was originally developed for the treatment of insertional desmopathies in man. ESWT involves the use of shock or pressure waves that are transmitted into the tissues to which the hand piece is applied. Both focused and non-focused units have been used, although there are little data comparing these machines to indicate a significant difference. The mechanism of action of ESWT on tissues is unclear. Significant effects have been shown in experimental studies,[21] but it is possible that these effects are deleterious. Therefore, this author does not consider ESWT to be appropriate for the management

of acute tendinopathy. One of the most convincing explanations for its effectiveness clinically is the induction of analgesia by an effect of sensory nerves.[22] The most frequently reported use of ESWT in horses has been for the treatment of proximal SL desmitis (PSLD) where it has shown a significant improvement in prognosis over conservative treatment for chronic hindlimb PSLD. Forty-one percent of hindlimb cases returned to full work within 6 mo of diagnosis[23] compared with the previously reported 13% for conservatively managed cases.[24]

3. Rehabilitation—The Use of Physical Forces to Influence Healing

Immediate controlled passive mobilization of the limb has been advocated in the acute phase of tendon and ligament injury in man to reduce inflammation and improve healing.[25] To be successful, the degree or frequency of mobilization must remain below the patient's pain threshold. This can be administered by a 15-min session of gentle physical therapy. The session should involve a series of 10–30 passive carpal and MCP joint flexions as long as they are tolerated by the horse.

Controlled exercise is an intrinsic part of the rehabilitation of tendon and ligament injuries, and it also helps to resolve residual inflammation, maintain gliding function, and promote optimal collagen remodeling.[26] Most SDFT injuries require at least 8–9 mo of rehabilitation before resuming full athletic function, although some may require up to 18 mo. It is rarely necessary to prolong rehabilitation longer than this, because healing seems complete by this stage.

A suitable exercise rehabilitation program should be created based on the severity of the ultrasonographic appearance of the lesion. The aim of the program is to provide a controlled and ascending exercise regimen that optimizes scar tissue function without causing further injury. This is difficult to predict because of the variability between animals. Therefore, the program should be adapted based on serial ultrasonographic monitoring and clinical signs such as lameness, heat, and swelling.

Ultrasonographic monitoring of the tendon/ligament should include measurements of tendon CSA. An increase in the CSA of >10% between examinations would suggest a degree of reinjury, and in such cases, the level of exercise should be reduced.[27] Because there is a sudden increase in strain levels in the SDFT and SL with an upward transition in gait from walk to trot, trot to canter, and canter to gallop, ultrasonographic examinations before and after these transitions can help to determine if the injured tendon/ligament can withstand the increased strain levels.

2. Pharmacological Management

1. Anti-Inflammatory Systemic Medication

Both systemic corticosteroids and non-steroidal anti-inflammatory drugs can be considered for the management of tendon/ligament inflammation in the acute stages. Phenylbutazone is commonly used at a dose of 2.2 mg/kg, q 12 h; however, the clinical effects of this drug seem to be more analgesic than anti-inflammatory.[28] Systemic steroids can be administered early in the acute inflammatory stage of the injury (usually within the first 24–48 h post-injury), and they are very effective. They should be avoided during the healing phase, because they also inhibit fibroplasia and therefore, repair of the tendon.[29,30] The induction of laminitis with systemic steroids represents a small, but nevertheless real, risk. In the author's opinion, this is less likely in Thoroughbreds compared with Warmbloods. Topical or IV dimeythl sulphoxide (DMSO) may reduce the inflammation, but a study has shown that 40–90% topical medical grade DMSO may weaken normal tendon tissue.[31]

Polysulphated glycosaminoglycans (PSGAGs) have been shown to inhibit collagenases and metaloproteinases as well as inhibit macrophage activation, but they were shown to have no effect on fibroblasts.[32] Thus, this drug can be viewed as a soft tissue anti-inflammatory agent. PSGAGs have been widely used for the treatment of tendinopathy and desmopathy. They are most commonly administered systemically through intramuscular injection, although they can also be given by intralesional injection.[33] Evidence for efficacy is limited; however, improved echogenicity of collagenase-induced superficial digital flexor tendinitis and faster resolution of core lesions treated with intralesional PSGAGs was demonstrated.[34] No significant difference in reinjury rates between horses treated with PSGAGs compared with controlled exercise alone has been shown.[35]

2. Intralesional Medication

Intralesional tendon and ligament treatment can be performed under standing sedation and local analgesia or under general anesthesia. It is preferred that it be performed with the leg bearing weight. Although the technique is frequently performed blindly by injecting where least resistance within the tendon is detected, accurate placement of the needle in the center of the lesion is best achieved using ultrasonographic guidance. The skin overlying the tendon or ligament to be injected should be clipped and aseptically prepared, and if ultrasonographic guidance is used, a sterile sleeve should be placed over the probe. A 2.5-cm, 23-g hypodermic needle can be used for most intratendinous treatments, but it varies with the viscosity of the agent. Intralesional treatment should not be administered until 3 days after the injury, because there is potential to increase hemorrhage. The volume injected into the tendon or ligament will depend on the extent of the lesion. Large volumes can be potentially damaging to the healing tendon.[36] In addition to PSGAGs, the other agents most frequently used for intralesional medication are hyaluronic acid (HA),

corticosteroids, and beta-aminoproprionitrile fumarate (BAPN).

HA is a component of tendon matrix and has been administered peritendinously, intralesionally, and systemically to treat tendinitis. In a study of collagenase-induced digital flexor tendinitis, HA was found to minimize tendon enlargement compared with controls; however, histopathological examination of the tendons failed to show a significant difference in the degree of inflammation.[37] Peritendinous HA has been shown to have no effect on ultrasonographic or histological appearance, biomechanical properties, or molecular composition of tendons in collagenase-induced tendinitis compared with controls, although it did appear to reduce lameness.[38] A review of the effectiveness of various medications has failed to show a significant difference between the reinjury rates of horses with SDFT tendinitis treated with intralesional HA compared with conservative treatment.[35] The drug is probably most appropriately used in the reduction of severity of adhesions after intrathecal injury.[39]

Corticosteroids, at least the depot preparations such as methylprednisolone, should not be injected directly into tendons or ligaments, because they have been shown to cause dystrophic tissue mineralization and tissue necrosis, most likely a consequence of the carrier.[40] Peritendinous or systemic use in the early stages are appropriate and can be used judiciously.

BAPN, a lathyrogen that inhibits the enzyme lysyl oxidase that normally forms cross-links between collagen fibers, has been used to treat tendinopathy. The rationale for its use is to allow exercise to promote alignment of newly formed collagen fibrils while preventing them being fixed in a haphazard fashion by cross-linking. BAPN does not hasten the resolution of the tendinitis, but it aims to improve the structure of the repaired tendon. Early experimental studies in collagenase-induced models of tendonitis appeared to show improvement in both the ultrasonographic appearance[41] and the histological collagen alignment.[42] However, more recently, concerns have been raised over its efficacy based on observations that BAPN reduces collagen synthesis[43] and showed no improvement over controls in a rabbit model of tendinitis.[44] Clinical studies have suggested that the reinjury rate of limbs treated with BAPN was reduced, although the rate for both limbs was no different from other treatments. This is caused by the fact that both limbs should be treated, because unilateral treatment increases the loading/reinjury risk on the contralateral limb. However, the drug has been withdrawn from the market and therefore, is now rarely used.

3. Surgery

1. Tendon Splitting

Tendon splitting was initially advocated as a treatment for chronic tendinitis to improve blood flow to damaged tendon tissue. The technique fell out of favor when subsequent research showed extensive granulation tissue formation, increased trauma to the tendon tissue, and persistent lameness post-treatment.[45] Tendon splitting is, therefore, no longer recommended for the treatment of chronic tendonitis. However, it is now thought to be more relevant for the management of acute cases where there is an anechoic core lesion evident on ultrasonographic examination that indicates the presence of a seroma or hematoma. It has been hypothesized that the presence of a core lesion within a tendon produces a "compartment syndrome," which results in decreased perfusion and ischemia of the region. The aim of tendon splitting in acute cases is to decompress the core lesion by evacuating the serum/hemorrhage and to facilitate vascular ingrowth. Removal of the fluid within the core lesion may also reduce proximodistal propagation of the lesion. In a collagenase-induced model of tendinitis in six horses, tendon splitting using the knife technique resulted in a faster resolution of the core lesion, a quicker revascularization of the lesion, and an increased collagen deposition relative to controls.[46]

Tendon splitting may be performed under standing sedation or under general anesthesia. It can be done blindly or using ultrasonographic guidance, which minimizes damage to normal tendon tissue by enabling the needle or knife to be inserted at a point where the core lesion is closest to the periphery of the tendon. A #11 scalpel blade or double-edged blade is inserted into the tendon and "fanned" proximally and distally. Alternatively, the procedure can be achieved with multiple insertions of a 23-g needle. This may cause less damage to the remaining, relatively intact tendon tissue. Furthermore, needle splitting may be combined with various intralesional treatments, although multiple needle injections may provoke leakage of the drug/agent out of the tendon.

After tendon splitting has been performed, a modified Robert Jones bandage should be applied. The horse should be rested in a box stall for 10–14 days, subsequent to which a controlled exercise program should be initiated.

2. Desmotomy of the Accessory Ligament of the SDFT

The aim of desmotomy of the accessory ligament of the superficial digital flexor tendon (or superior check ligament desmotomy (SCLD)) is to produce a functionally longer musculotendinous unit to reduce strain on the SDFT.[47] However, it has been shown in equine cadaver models that SCLD actually increases the strain on the SDFT and SL during loading because of increased extension of the MCP joint.[48] The biomechanical alterations of SCLD are complex, and it is recognized that studies using cadaver limbs may not represent the biomechanical events in a fatigued galloping racehorse. However, increased risk of injury of the SL after the SCLD has been performed has also been shown in vivo.[49]

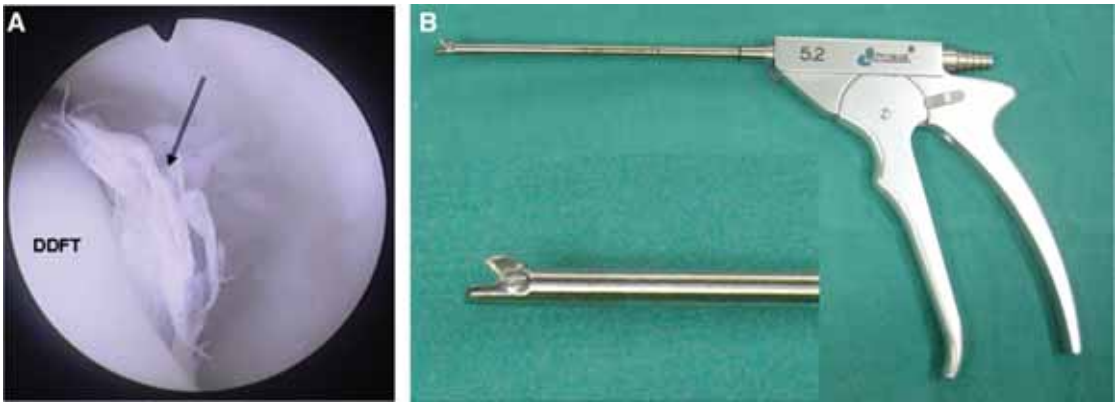

Fig. 13. Tenoscopic appearance of a tear in the lateral border of the DDFT. The torn fibers are debrided using a (A) mechanical synovial resector, arthroscopic scissors, or (B) suction punch biopsy forceps.

SCLD can be performed using a percutaneous approach[50] with the horse in lateral or dorsal recumbency. More recently, however, this procedure has been carried out tenoscopically through the carpal sheath.[51] With the affected limb uppermost and partially flexed, an arthroscopic portal is created into the carpal sheath 2 cm proximal to the distal radial physis on the lateral side of the limb. An instrument portal is made immediately proximal to the distal radial physis. With the limb in 90° flexion, the accessory ligament is visualized on the medial aspect of the sheath and cut using a #10 scalpel blade on a long handle or meniscectomy knife. The very proximal portion of the ligament cannot be visualized directly, but it is transected by careful dissection using punch biopsy forceps. Care must be taken to avoid perforating the blood vessel at the proximal limit of the accessory ligament.

3. Tenoscopy

The increasingly widespread use of tenoscopy has shown a high frequency of intrathecal tendon tears that are associated with tenosynovitis and lameness. Thus, horses presenting with tenosynovitis with pain on palpation of the proximal digital sheath and lameness should always be considered candidates for tenoscopic evaluation. Based on a recent survey of cases, tears in the DDFT (Fig. 13) are more commonly found in forelimb digital sheaths, whereas tears to the manica flexoria are more commonly found in hindlimbs. Ultrasonographic evaluation usually reveals non-specific changes of synovial hypertrophy, and it is frequently not possible to identify tears on ultrasonographic examination with confidence. In addition, tears can also be found and debrided tenoscopically in the SDFT and DSL within the digital sheath. Tears of other tendons and ligaments communicating with a synovial cavity have been seen associated with synovial distension and lameness (e.g., in the SL branches into the metacarpal/metatarsal joint).

Tenoscopy of the digital sheath requires general anesthesia and can be performed in lateral or dorsal recumbency. However, dorsal recumbency allows easier access to both sides of the digital sheath and is recommended. Arthroscopic portals are created immediately distal to the proximal sesamoid and 1–2 cm palmar/plantar to the neurovascular bundle.[52] This allows evaluation of the proximal and distal parts of the digital sheath, although distal visualization can sometimes be easier with the arthroscope inserted through a portal in the proximal digital sheath (e.g., as for a proximal instrument portal). Instrument portals are created where appropriate to allow debridement of any tendon tears with a mechanical resector, arthroscopic scissors, or suction punch biopsy forceps (Fig. 13). This may require the instrument portals to be extended through the synovial reflection that attaches to the proximal border of the manica flexoria to allow access to DDFT tears located within or proximal to the manica. Although manica tears can also be debrided in a similar fashion to the DDFT tears, in the author's opinion, this has resulted in a poorer outcome than with complete removal. Because no adverse effects have been observed with complete removal, this is recommended for all except for the most minor manica tears. Removal requires transaction of both medial and lateral attachments to the SDFT as well as the synovial attachment to the proximal border of the manica. This is facilitated by an assistant maintaining tension on the manica with rongeurs through the contra-axial proximal instrument portal. Transection can be achieved with arthroscopic scissors or a hook knife.

Adhesions can also be resected during tenoscopic evaluation, and the palmar or plantar annular ligament can be transected if it is believed to be involved in the pathology. Post-operatively, the horse should be strictly rested for at least 2 wk. After that period, hand walking can be started and gradually increased over a minimum period of 6 wk.

Thereafter, the duration of rehabilitation will depend on the severity of the injury. The prognosis for DDFT tears (~20%) is worse than for manica tears (~80%).[11]

4. Annular Ligament Desmotomy

Annular ligament desmotomy has been most frequently advocated as a treatment of annular ligament syndrome where there is a relative constriction of the tendons within the fetlock canal. This constriction can be either primary or secondary to other pathology within the digital sheath.[53–55] Consequently, desmotomy has been advocated for the management of DDFT and SDFT lesions in the region of the metacarpal/metatarsal joint. Usually, the procedure is indicated if the annular ligament is impeding the normal gliding function of the flexor tendons. It is probably rarely necessary, because the prognosis is closely related to the primary pathology. Desmotomy is, therefore, best performed tenoscopically using a hook knife rather than through closed or open techniques, because it is less traumatic, ensures accurate transection of only the PAL, and allows evaluation of the tendons to identify any surface defects.

5. Fasciotomy and Neurectomy of the Deep Branch of the Lateral Plantar Nerve for the Treatment of PSLD

Surgery has been advocated in cases of PSLD of the hindlimb that are unresponsive to conservative management. It has been reported that horses have returned to high-level competition after tibial neurectomy to treat PSLD.[34] However, a more specific neurectomy of the deep branch of the plantar nerve has been recently described.[56] This was performed under general anesthesia with the horse in dorsal recumbency. An incision 4–6 cm wide, which originates proximally from the level of the chestnut, is made adjacent to the lateral border of the SDFT. The plantar metatarsal fascia is incised, and the incision is extended deep to the SDFT by blunt dissection, which is facilitated by retraction of the SDFT. The lateral plantar nerve is located in connective tissue, and the deep branch is identified. It is then transected using a scalpel, and a 3-cm section is removed. The connective tissue fascia covering the SL is subsequently cut (fasciotomy) adjacent to the lateral splint bone to "decompress" the origin of the SL, because hindlimb PSLD is believed to be associated with a compressive "compartment" syndrome involving the plantar metatarsal nerves.

Post-operatively, only a short period of strict rest is needed (~2 wk) to allow the surgical incisions to heal. Thereafter, the horse can gradually begin a controlled, ascending exercise program.

Unpublished reports have suggested that this technique is associated with a high level of success (79%) in returning affected animals to full work with minimum risk of exacerbating the desmitis.

4. Alternatives

The effect of ultrasound, laser, and magnetic fields on tissues is not completely understood. It is thought that the main effect of ultrasound is the conversion of sound energy into thermal energy. Although there is a paucity of scientifically convincing research into the effects of ultrasound for the treatment of equine musculoskeletal disorders, a study by Morcos and Aswad[57] showed that the use of therapeutic ultrasound resulted in increased vascularization and fibroblastic proliferation compared with controls in experimentally split equine tendons.

Low-level laser therapy has been shown to stimulate cellular metabolism and enhance fibroblast proliferation and collagen synthesis in vitro.[58] There are, however, no clinical trials showing a significant difference between laser-treated and control cases of tendinopathy or desmopathy.

Despite its widespread use by horse owners and anecdotal reports of its efficacy, magnetic therapy has not been shown to enhance tendon or ligament healing in any clinical trials.

Counter irritation ("firing") has long been used in equine practice for the treatment of tendon and ligament injuries in the form of chemical or thermal cauterization. Topical iodine and mercurial-based compounds have been used for chemical cauterization or "blistering" of tendon injuries. Thermal cauterization or "firing" is performed under general anesthesia or standing sedation with local analgesia using heated bars or pins that are applied to the skin over the injured tendon or ligament. In some cases, the tendon is penetrated with the heated pins. Studies have shown that there is no histological difference between the collagen arrangement within the scar in cases of tendinopathy treated with firing compared with controls.[59] It has been postulated that any benefits from firing result from the enforced rest, local release of inflammatory cytokines, and/or a protective "bandage" of fibrous tissue/skin that will support the tendon. The limited controlled studies that have been performed on firing have concluded that it is not an effective treatment for tendon and ligament injuries.[59]

5. Tendon Lacerations

1. Emergency Treatment of Tendon Lacerations

The limb should be stabilized using a splint and a support bandage before the horse is moved to an appropriate place for treatment. It is important that the limb is supported to ensure the comfort of the horse. This may help to restore some biomechanical function of the limb and prevent further tissue damage. It is particularly important to avoid further trauma to the neurovascular structures of the distal limb. For flexor tendon lacerations, a palmar or dorsal splint or a commercial splint should be applied.

2. Surgical Repair

Surgical repair of flexor tendon lacerations involves debridement, with or without suturing of the tendon, and closure of the wound, usually performed under general anesthesia in lateral or dorsal recumbency. The aim of tenorraphy is to restore tendon gliding function, minimize gap formation between the tendon ends, minimize adhesion formation, and preserve functional vasculature. If the laceration is complete, the tendon may have recoiled, requiring proximal and distal extension of the skin wound in an elongated "S" to locate both tendon ends. Flexing of the metacarpal/metatarsal joint may facilitate locating of the distal tendon end. The wound and tendon ends should be debrided and lavaged. If the tendon ends can be apposed, tenorraphy can be performed using a monofilament absorbable suture (e.g., polydioxanone or polyglyconate). Non-absorbable materials should be avoided, because this can result in shearing between the healed tissue and the suture material. It may be responsible for persistent lameness. Two suture patterns have been commonly used—the three-loop pulley and the interlocking loop.[60] The three-loop pulley is strongest, and it prevents distraction of the ends of the tendon under loading ("gapping"). The interlocking loop has little suture material outside the tendon, and it is, therefore, the recommended technique for repair of intrathecal lacerations.

Frequently, however, the injury is associated with significant blunt trauma to the tendon ends, which precludes direct apposition of the tendon ends. In this situation, the tendon ends are left after debridement, the wound is closed, and the limb is cast, or an implant can be used to maintain the alignment of the tendon ends. The ideal tendon implant material would have similar biomechanical properties to normal tendon. Various implant materials have been used to repair lacerated flexor tendons including carbon fiber, terylene (polyester), autologous extensor tendon grafts, absorbable tendon splints, and poly-L-lactic acid (PLLA).[61] Carbon fiber implants were associated with persistent lameness postoperatively. This may have been caused by tenalgia that results from shear forces between inelastic carbon fibers and the healed tendon tissue. Autologous grafts with extensor tendons can be used to bridge the deficit between two ends of a lacerated tendon, but this technique has never gained popularity. PLLA has an advantage in that it supports fibroblast growth on its surface and loses its strength over several months. Therefore, it is able to match its mechanical properties with the tendon. Implants are anchored in each end of the lacerated tendon by fixing the ends in V incisions created in the tendon ends with sutures of monofilament absorbable sutures. The tendon splints have a semicircular cross-section and can be sutured to the tendon ends through holes in the splints. Implants are not recommended as a treatment for strain-induced tendinopathies.[62]

Partial lacerations involving $<50\%$ of the tendon may need only local debridement. Lacerations involving $>50\%$ of the tendon are probably best sutured, because this can prevent the generation of longitudinal splits between loaded and unloaded parts of the tendon or the failure of the remainder of the tendon under weight-bearing load.

Flexor tendon lacerations require a protracted rehabilitation period. A distal limb cast should be placed with forelimb lacerations post-operatively. In the hindlimb, a full limb cast is ideally required after flexor tendon laceration to immobilize the forces of the reciprocal apparatus. Distal limb casts can be used in the hindlimb to avoid the increased risk of complications with full limb casts. However, if an implant has been placed, this usually results in one end being pulled out of the tendon. Casting is required for a minimum of 6–8 wk and no more than 10–12 wk, because studies have shown that the breaking strength of the tendon repair at 6 wk approximates the body weight of the horse.[63] This means that usually at least one cast change under general anesthesia is needed.

Support of the metacarpal/metatarsal joint using a palmar/plantar splint with a modified Robert Jones bandage and caudal shoe extensions (for DDFT lacerations) can help protect the repair after cast removal. Continued box-stall rest is necessary for an additional 2–3 mo after which walking exercise followed by an ascending exercise regimen can be initiated. Ultrasonographic monitoring of tendon healing is useful to assess the integrity of the tendon repair. A minimum of 8–12 mo is usually required before full athletic function can be resumed.

The prognosis for flexor tendon injuries is guarded. In one study, ~45% returned to athletic function,[63] whereas in another study, the prognosis was 59% for flexor tendon lacerations.[64] In the second study, the prognosis for return to soundness was not increased if the DDFT and SDFT were simultaneously lacerated compared with if only a single structure was lacerated. Short-term complications include necrotic tendonitis, which occurs as a result of infection or damage to the vascular supply, concurrent synovial sepsis, cast complications, and exuberant granulation tissue formation. Long-term complications include adhesions, which result in continued pain and lameness, and occasionally, flexural deformity.

In contrast to the flexor tendons, extensor tendons heal remarkably successfully without tenorraphy, and they respond well to conservative management. The wound should be debrided, and the primary wound should be closed, if appropriate. If the extensor tendon has been lacerated within the confines of a tendon sheath (e.g., for extensor lacerations over the dorsal aspect of the carpus), lavage and elimination of sepsis from the tendon sheath also needs to be addressed. The prognosis for extensor tendon

lacerations is good with ~72% of horses returning to athletic function.[65] Other sources report an 80% good prognosis,[64] because the extensor tendon bears considerably less load. Additionally, it has a minimal effect on the gait, because most protraction of the limb and digit arises from the upper limb and momentum of the foot. Indeed, a recent publication reported the successful management of septic common digital extensor tenosynovitis by complete resection of the tendon.[66] Stumbling may be evident at the walk until the tendon has healed, but it can be reduced by shortening the toe of the hoof and rolling the toe of the shoe or by fitting a "Natural Balance" type shoe.

6. New Advances—the Evolution of Biologics

So far, none of the accepted treatment methods seems to be consistently more efficacious than any other for long-term return to racing without reinjury. After injury, tendon heals (repairs) well, but the scar tissue that replaces the damaged tendon is less functional than normal tendon tissue. This results in reduced performance and a substantial risk of reinjury. To avoid these adverse consequences, an ideal treatment should, therefore, aim to avoid the formation of excessive fibrous tissue and be able to regenerate normal tendon matrix. Spontaneous regeneration of tendon post-injury does not seem to occur. This is most likely because the endogenous stem cell response is inadequate: cells recovered from tendon show poorer differentiation capacity than bone-marrow cells.[67] In addition, the cellular infiltration, although initially dominated by blood-born cells derived from the bone marrow that are likely to be white blood cells involved in local debridement of damaged tissue, is later substituted by more long-lasting cellular infiltration, which is probably derived from local surrounding tissues like the paratenon.[68] This provides further support for a technique of exogenous administration of bone marrow-derived stem cells.

The aim of regenerating tendon tissue involves a tissue engineering approach that has been proposed to depend on four separate components: an appropriate mechanical environment, a scaffold, an anabolic stimulus, and a cell source.[69] Each of these components can be used individually, although the maximum effect is believed to occur with a combination of all four.

1. Scaffolds

Scaffolds can have a variety of potential beneficial effects. They can be used to carry or attract cells, help align reparative tissue by their structure, and protect the cells immediately after implantation and before new matrix has been synthesized. However, their influence can be both positive and negative.

ACell Vet is a novel intralesional treatment for tendinopathy/desmopathy using acellular tissue components derived from porcine urinary bladder submucosa. This preparation has been suggested to deliver appropriate growth factors to the injured tissue as well as attract mesenchymal stem cells. It is injected in liquid form as a reconstituted powder. However, it has been associated with significant inflammatory reaction after injection. It is recommended that horses are premedicated with anti-inflammatories and that cold is applied locally after treatment. It has mostly been used to treat chronic SL disease where there are anecdotal reports of benefit, although no objective data has yet been published of its efficacy.

2. Growth Factors

Insulin-like growth factor-1 (IGF-1) has been investigated to assess its effect on tendon healing both in vitro and in collagenase-induced models of tendinitis.[70] IGF-1 stimulates extracellular tendon matrix synthesis and is also a potent mitogen.[70] In collagenase-induced models of tendinitis, initial swelling was decreased after intralesional injections of IGF-1 compared with controls. However, no differences were found at later time points, and there was no difference between the quantities of type I and type III collagen synthesized.[70] Currently, there is no published long-term follow-up data regarding reinjury rates of tendinitis treated with IGF-1.

Equine recombinant growth hormone (rEGH) administered intramuscularly has shown a negative effect on the biomechanical properties (decreased yield point and ultimate tensile strength) of the SDFT during the early phases of healing in collagenase-induced tendinitis.[71] These properties were, however, assessed at 6 wk after treatment, which may have been too soon to detect any beneficial effects of the rEGH.

Transforming growth factor-beta (TGF-β) has been considered as another appropriate growth-factor treatment, although clinical experience has been limited. Treated horses showed significant enlargement of the tendon. Reinjury rates were similar to conservatively managed horses, but these reinjuries were all on contralateral, untreated limbs.[c]

Platelet-rich plasma (PRP) is becoming more commonly used for the treatment of tendon and ligament injuries. It is usually defined as having >4 times the platelet count of normal blood, and it can be prepared by either centrifugation or filtration (Fig. 14). PRP contains high levels of those growth factors sequestered in platelets like TGF-β1, IGF-1, and platelet-derived growth factor (PDGF). It is not known if these growth factors are optimum for tendon and ligament healing, but they do have anabolic effects[72,73] and are, therefore, logical factors to use. However, it may be that PRP will serve to promote an exaggerated fibrotic reaction rather than regeneration. Given this concern, PRP is probably most suited to the treatment of SL lesions. Evidence of efficacy is still lacking, but small clinical studies have been positive.[74]

Fig. 14. fPRP[a] system for preparing plasma rich in platelets. This system uses a filtration system for concentrating the platelets rather than centrifugation, and it is a closed system that can be used "horse side."

3. *Mesenchymal Stem Cells*

Stem cells have the potential of differentiating into a number of tissues.[75–79] Embryonic stem cells are truly pluripotential but have the disadvantages of being allogenic (although with greater immunological tolerance) and being associated with a risk of teratoma formation. Postnatally derived stem cells are thought to be multipotential or have a restricted number of cell lineages into which they can differentiate. They are subdivided into hemopoietic (blood-cell lines) and mesenchymal stem cells (MSCs), which can give rise to osteoblasts (bone), chondrocytes (cartilage), tenocytes (tendon and ligament), fibroblasts (scar tissue), adipocytes (fat), and myofibroblasts (myotubes). Furthermore, these stem cells can be recovered from adult tissue, and thus, there is the possibility of autologous reimplantation. This also has the added benefit that they do not incite an immune response from the host. Such stem cells are most easily recovered from bone marrow, although other workers are considering the use of fat-derived stem cells. These preparations are, however, less well characterized at present.

The differentiation of the MSCs into tenocytes is believed to be induced by a combination of mechanical (tension) cues, growth factors, and contact with "like" cells and matrix, most, if not all, of which are provided by implantation within the tissue.

There is currently much interest in the use of stem cells to "engineer" new tissue. Clinically, MSCs are currently being used for the treatment of ischemic heart disease in man with encouraging results of survival and increased cardiac output. The transplantation of MSCs into injured skeletal tissues has been shown to promote healing in a multitude of studies in experimental animals. In tendon, studies have used surgically created defects in tendons and ligaments of laboratory animals and have all shown significantly improved outcomes with the implantation of bone marrow (BM)-MSCs.[53–55]

The equine SDFT injury has a different etiopathogenesis. However, it is ideal for the implantation of MSCs, because there is usually an enclosed defect within the tendon that can retain implanted MSCs without the need for a scaffold.

There are several techniques currently employed clinically: direct administration of bone marrow, use of fat-derived stem cells, and autologous implantation of MSCs.

1. The direct intraligamentous (or intratendinous) administration of bone marrow has been reported to show promising results in the treatment of SL disease.[80] However, there are very few MSCs present in a bone-marrow aspirate (~1 MSC per 10^5 nucleated cells), which has led some to suggest that this treatment more resembles a growth-factor treatment than a true cell-based therapy. Certainly, the supernatant of bone marrow has been shown to contain a rich mix of anabolic factors.[81] Furthermore, the injection of large volumes (20–30 ml) cannot be fully retained in the structure, and together with the presence of other cell types and tissues (e.g., bone spicules), it can potentially be damaging to the healing tendon or ligament, especially by inducing ectopic calcification.
2. The above technique using BM-MSCs has received the most basic science research and aims to provide a pure source; however, VetStem[b] in the United States has used another source of stem cells from fat (Fig. 15). This technique involves collecting fat from the

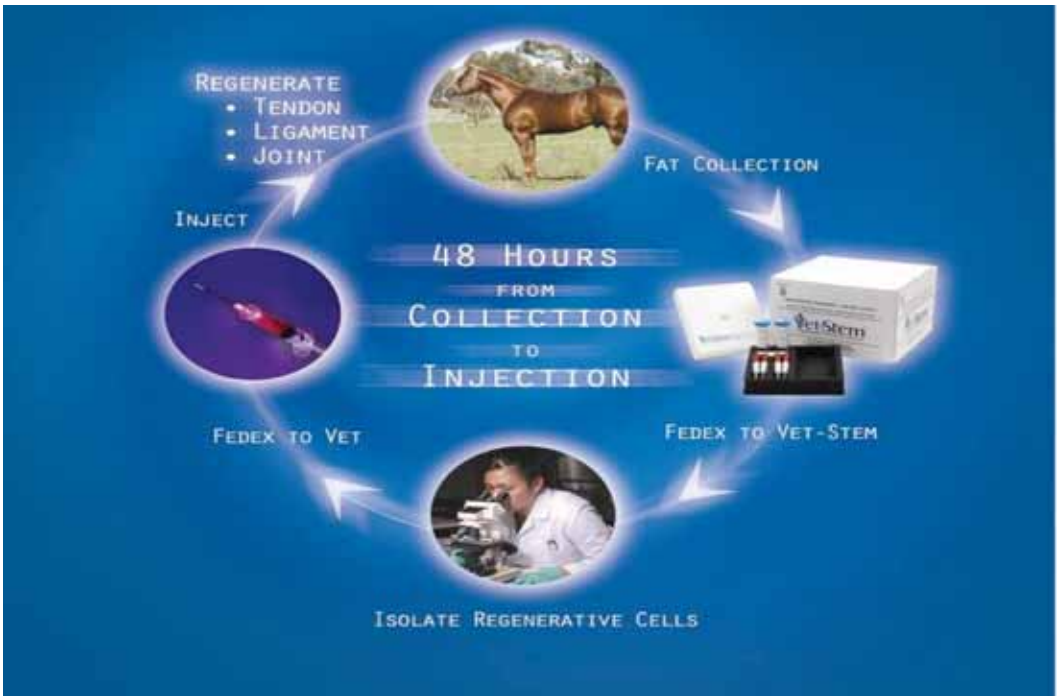

Fig. 15. The Vet-Stem[b] system for the treatment of tendon and ligament injuries with fat-derived cells.

tail head, digesting the tissue, and removing the fat cells. This leaves a mixture of cells that includes the adipose-derived stem cells (~2%), which are shipped back to the veterinarian without further purification for intratendinous injections.

3. In contrast, we have been developing an alternative approach involving the implan-

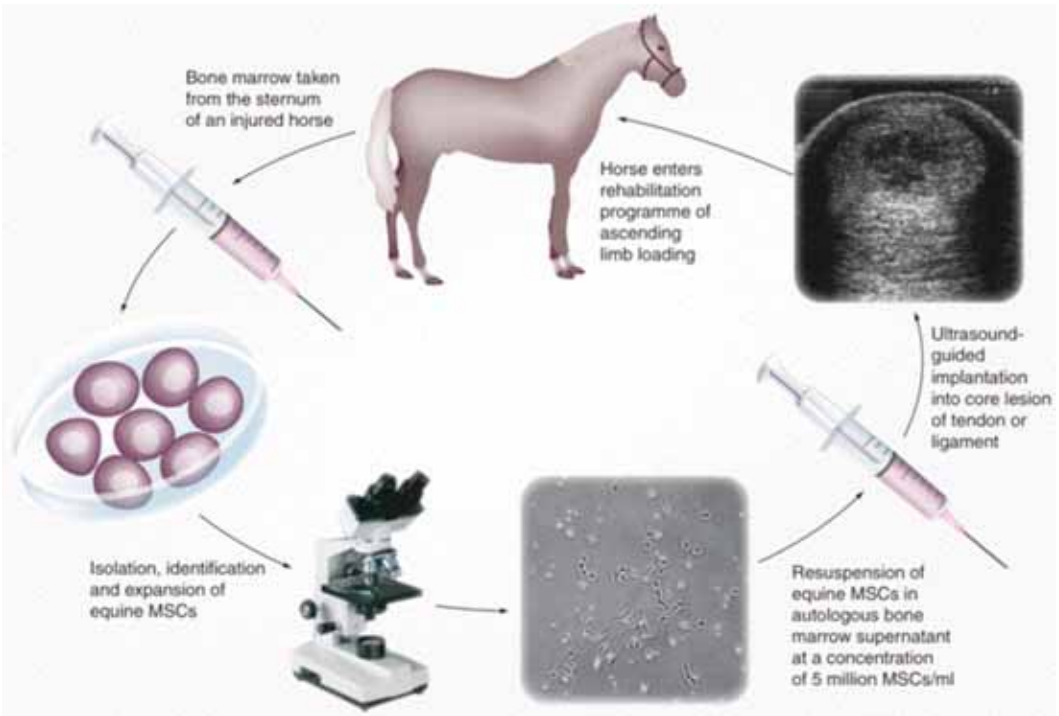

Fig. 16. The VetCell technique for the treatment of tendon and ligament injuries with autologous BM-MSCs.

Table 1. Typical Exercise Program After Tendon Injury (NB This program should be shortened or lengthened depending on the severity and progress of the case)

Exercise Level	Weeks	Duration and nature of exercise
0	0–2	Box rest
1	3	10 minutes walking
1	4	15 minutes walking
1	5	20 minutes walking
1	6	25 minutes walking
1	7	30 minutes walking
1	8	35 minutes walking
1	9	40 minutes walking
1	10–12	45 minutes walking daily
	Week 12	Repeat ultrasound examination.
2	13–16	40 minutes walking and 5 minutes trotting daily
2	17–20	35 minutes walking and 10 minutes trotting daily
2	21–24	30 minutes walking and 15 minutes trotting daily
	Week 24	Repeat ultrasound examination
2	25–28	25 minutes walking and 20 minutes trotting daily
2	29–32	20 minutes walking and 25 minutes trotting daily
	Week 32	Repeat ultrasound examination
3	33–36	45 minutes exercise daily with slow canter
3	37–40	45 minutes exercise daily with slow canter
3	41–44	45 minutes exercise daily with fast work three times a week
3	45–48	45 minutes exercise daily with fast work three times a week
	Week 48	Repeat ultrasound examination
4	From 48 wks	Return to full competition/race training

tation of large numbers of autologous MSCs derived from bone marrow and expanded in the laboratory (Fig. 16). We hypothesized that the implantation of marrow-derived stromal stem cells (BM-MSCs) directly into the central cavity of an injured SDFT would provide all four of the requirements for effective tissue engineering.

- The cells within the tendon would experience the tensional load placed on the tendon.
- They would be injected into a scaffold of granulation tissue that is highly vascularized. This provides maximal chance of cell survival, even with large lesions.
- The cells are implanted with the supernatant of the bone marrow from which they were derived. This has a pronounced anabolic effect on equine ligament cells that is greater than that of other biological fluids, including platelet-rich plasma.[81]
- The use of BM-MSCs would have the potential of synthesizing a matrix that more closely resembles tendon matrix than scar tissue. Thus, this would improve functional outcome because of the increased capacity for a successful return to performance without reinjury.

Our technique (developed in conjunction with Vet-Cell Bioscience Ltd.) involves the collection of bone marrow from the sternum in the standing sedated horse followed by isolation and expansion of the nucleated adherent cell population (containing the MSCs) in the laboratory.[77] After ~3 wk, in excess of 10×10^6 cells are available for implantation. The cells are suspended in bone-marrow supernatant, because this has been found to have a beneficial mix of growth factors. Then, they are implanted under ultrasonographic guidance into the core lesion of the tendon or ligament under standing sedation.

The horses then enter an ascending exercise regimen aimed at providing a controlled, mechanically appropriate (tension) environment for the cells. This consists of initial rest for 7 days (for the cells to establish themselves) and is followed by walking exercise for 3 mo. Thereafter, trotting is introduced after 3 mo and is followed by cantering after 9 mo and full work at 12 mo. Regular ultrasonographic monitoring is advised at 1, 3, 6, 9, and 12 mo post-implantation.

Initially, a Phase I trial was performed to ensure safety. This consisted of six horses with large core lesions in their SDFTs that were followed for up to 12 mo. Results indicated that the technique did not cause any worsening of the injury, and there was no reaction or enlargement of the tendon post-implantation. Furthermore, no bone or cartilage was formed based on gamma scintigraphy and ultrasonography after 3 mo. Core lesions filled in quickly when a hypoechoic lesion was still visible at the time of implantation. The longitudinal pattern,

however, remained inferior to normal tendon but improved with exercise.

Since the initial trial, in excess of 500 horses have been treated with this technique. At the most recent evaluation of clinical outcome (September 2007), 172 racehorses had been treated with >1 yr follow-up. For National Hunt racehorses (n = 145), the reinjury rate was 18% (23% when injuries to untreated contralateral limbs were included). When only those horses that had entered full training were included, the reinjury rate rose slightly to 24% (33% with contralateral reinjuries). These percentages have remained relatively constant for up to 3 yr after treatment, although numbers are small for the longest follow-up. However, these data compare favorably with previous analyses for the same category of horse (56% reinjury rate for National Hunt horses[14]) for analysis of horses used for the same discipline followed for 2 yr after a return to full work. In further support for this improvement in outcome, reinjury rates for sports horses (all disciplines combined; n = 109 with >1 yr follow-up) was improved by a similar degree (13% compared with 23–43% reported for different sport-horse disciplines[35]).

We proposed that the optimum time to implant the cells is after the initial inflammatory phase but before fibrous tissue formation. It was hypothesized that the presence of mature fibrous tissue within the tendon would (1) make implantation more difficult and (2) reduce the benefits of the stem-cell therapy because of its persistence. Both have been supported by clinical experience of delayed implantation of BM-MSCs and outcome. Successes had an average interval between injury and implantation of 44 days, whereas horses suffering reinjury had an average interval of 83 days ($p = 0.0035$). Current recommendations are that bone marrow is aspirated within 1 mo of injury. For the same reason, known recurrent injuries are not considered ideal cases, because significant fibrosis would already be present. The time of implantation may be further optimized by pre-injury storage of cells.

Five cases that died through unrelated causes have been analyzed histologically and showed excellent healing with minimal inflammatory cells and crimped organized collagen fibers. In contrast, a contralateral untreated SL injury in one of these horses, which was clinically silent at the time of implantation, showed persistent inflammatory cells and poorly organized collagen fibers.

A more limited number of cases have been treated with injuries to other tendons and ligaments. For lesions present within a tendon sheath, the implantation is done after tenoscopic evaluation to ensure that there are no surface defects through which the cells could leak.

10. Conclusions

The extensive number of treatments available for the treatment of tendon and ligament injuries provides strong evidence that none are universally effective. Because of the natural variability of the disease, careful and objective assessment of large numbers of cases is essential to prove efficacy of a treatment. Treatment should be selected by stage and severity of disease, use of horse (racing is still the most severe test for an effective treatment), and follow-up time (reinjuries tend to occur when the horse is back racing but not before). This means that strong evidence-based treatments cannot be provided. The two most important aspects are to (1) obtain an accurate diagnosis of which structure is injured, including the stage and severity, and (2) apply treatments based on a strong scientific rationale with respect to the pathophysiology. Currently, combinations of treatments may offer the best approach (e.g., stem-cell treatment and SCLD). However, in many cases, cost implications may also influence the choice of combination treatments.

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TUMORS

Tumors or neoplasms are those benign or malignant over growths that can be observed anywhere over the body of the animal. *Malignant* tumors usually affect elder animals (squamous cell carcinoma) while *benign* tumors affect younger animals (warts).

Classification and characters:

Tumors classified into benign or malignant, and solitary or multiple.

1-Benign tumor

It is a localized tumor, doesn't recur after excision, slower in growth rate, doesn't ulcerate, and doesn't adhere to the skin.

2-Malignant tumor

It develops rapidly, metastatic, recur after excision, adhere to skin, and shows ulceration.

Diagnosis:

1-History.

2-Clinical signs.

3-Clinical examination

4-Histopathologic examination to confirm the diagnosis and to determine the nature of the tumor.

Treatment:

1-Benign Tumor

a-Ligature:

Pedunculated tumors can be removed by ligation with elastic or rubbery materials and the induced wound is dressed with antiseptic solution. The aim of use of ligature is to close the blood supply of the tumor and to hasten its separation and sloughing.

b-Hot Iron:

It controls bleeding, and causes necrosis and sloughing of the stump of the tumor.

c-Ecraseur:

The skin is incised and the chain is applied on the incision.

d-Wart Enucleator: I

t is a forceps with excavated jaws and sharp borders used for removal of warts.

e-Potential Caustics:

Like arsenal paste, nitric acid, acetic acid, salicylic acid, or liquor of potassae.

f-Surgical Excision:

2-Malignant Tumor

Generally, the success rate of treatment of malignant tumors is very low.

a-Radiotherapy:

The aim of use of this method is the destruction of malignant cells by gamma radiation. Anyway this technique is better to be used in adjunction with surgical de-bulking.

b-Cryotherapy:

It depends up on two cycles of freezing and thawing.

c-Immunotherapy:

By using BCG that is injected 1 ml/cm3 once a week for 4 weeks. Severe reaction and necrosis of the tissue occurs. This technique is used for treatment of sarcoma in equine.

d-Surgical Excision:

Alone, it is of no value.

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ULCERATION AND ULCERS

Definition:

Ulceration is the loss of superficial epithelial tissues leading to exposure of sub-epithelial of skin or mucous membrane with formation of wound has no tendency to heal. It differs from gangrene in that the latter term denotes the simultaneous loss of vitality of a considerable portion of tissue.

Causes:

1-Traumatic

2-Infection

3-Neoplasm

4- Repeat irritation of a wound (dog's ear, tip of the tail and angles of flexion**)**

5-Presence of foreign body or necrotic tissue that causes infection and prevents healing

6- Loss of innervation

7- Poor blood supply

Classification:

1-Traumatic ulcer due to trauma

2-Specific ulcer due to infection as in ulcerative lymphangitis, glanders, or T.B.

3-Malignant as rodent ulcer, epithelioma, and fungating ulcer due to streptococcus

farciminosus

Symptoms:

1-More or less rounded breach on the surface and varying in depth

2-The center of the lesion may be flat or concave and show necrotic spots

3-The borders may be hard or soft, and of the same level of the surroundings or higher

4-Usually it has serous, purulent, bloody, or grayish discharge

5-Old ulcer is surrounded by fibrous tissue and the edges are cut perpendicular and hard (*callus ulcer*).

6-If gangrene occurs at the level of the ulcer and extends rapidly in its depth due to bacterial destruction, the ulcer is called *phagedenic ulcer*

Diagnosis:

1-History

2-Clinical signs

3-Clinical examination

Treatment of ulcers:

1-Remove the cause

2-Apply antiseptic fomentation with moderate pressure bandage to promote healing

3-Astringent, thermo-cautery, or caustic applications can be used if the granulations are excessive or unhealthy, or for callus ulcer

4-Excession of the ulcer then suturing of the wound is the best treatment

5-Specific treatment for specific ulcers