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Diagnosis and Treatment of Flexural Deformities in Foals

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Flexural deformities represent deviations in the sagittal plane. They are divided into contractural and hyperextension deformities either congenital or developmental in origin. Diagnosis is usually straightforward and should lead to immediate treatment to prevent secondary complications. Inherited factors such as rapid growth response to high energy nutrition play an important role in the development of the problems; balancing nutritional intake is the key in the prevention of flexural deformities. While congenital contractural deformities are usually managed either by medical means (oxytetracyline IV) or application of special shoes (toe extensions), digital hyperextension deformities are usually handled through swimming exercise or the application of heel extensions—surgical intervention is rarely indicated. Surgical intervention is in most cases the treatment of choice in developmental contractural deformities—desmotomy of the accessory ligament of the deep digital flexor tendon for deformities of the distal interphalangeal joint and desmotomy of the accessory ligament of the superficial digital flexor tendon.
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Flexural limb deformities represent a complex problem, which is frequently discussed in the equine veterinary literature,[1-3] and its treatment was documented as early as the 5th century AD.[4] In this type of deformity the deviation is located in the sagittal plane and is expressed either as a hyperflexion or hyperextension of a joint region. Persistent hyperflexion is known colloquially as contracted tendons, even though in most cases the tendon units are not actually contracted—they are just functionally too short, relative to the associated osseous structures.[5] The type of deformity is named according to the joint involved and not the tendon and is classified as a contractural deformity. For the sake of completeness, hyperextension deformities, which are not part of the flexural deformity complex per se, are included and discussed as well.

Flexural deformities are diagnosed in the distal interphalangeal joint, the metacarpophalangeal or metatarsophalangeal joint, the carpal region, and, rarely, the tarsal region. Most often an animal suffers from one type of deformity only, but several areas can be affected in severe congenital contractural deformities. The forelimbs are more frequently affected, and in most cases the problem is seen in both forelimbs, one of them being affected more severely. Flexural deformities present at birth are referred to as congenital deformities, whereas acquired flexural deformities develop during the remainder of the animal's life.

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Congenital Deformities

Pathogenesis

Little scientific evidence exists about the origin of flexural deformities, with most causes mentioned being speculative in nature. Intrauterine malpositioning, a commonly mentioned cause of the problem, can only occur rarely in an abnormally large foal relative to the size of the mare, where intrauterine crowding leads to development of the problem. It is presently assumed that congenital flexural deformities are multifactorial in their origin and hence are difficult to explain.

Several diseases acquired by the mare during pregnancy can lead to the development of flexural deformities in the foal.[1] A multitude of agents and causes have been associated with the problem, including ingestion of locoweed and hybrid Sudan grass during pregnancy, a dominant gene mutation in a sire, equine goiter, an influenza outbreak, neuromuscular disorders, and defects in cross-linking of elastin and collagen caused by lathyrism.[6] The evidence in these cases may be only circumstantial, underscoring the need for further investigations into the development of congenital deformities.

An early report stated that 20% of 608 fetuses and newborn foals submitted for necropsy suffered from miscellaneous limb contractures,[7] which underscores the trend noted

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Figure 1 The rear limbs of 5-day-old foal with marked digital hyperextension. The sole of the feet are elevated in the air, while the weight is born on the bulb of both heels. (Color version of figure is available online.)

by clinicians that the incidence of flexural limb deformities is increasing.[8]

A flexural limb deformity, whether of contractural or digital hyperextension origin, is considered congenital when it is present at birth. The problem is easily recognized in most cases and should be evaluated by a veterinarian at that time.

Digital Hyperextension Deformities

Some newborn foals show a mild degree of digital hyperextension. The problem is caused by flaccidity of the flexor muscles[2] and usually corrects itself within a few weeks because of negative allometric growth of the tendons relative to the bones and increased muscle tone. In severe cases, the foals walk on the palmar or plantar aspect of the phalangeal region, where skin lesions rapidly develop as a result of abnormal loading (Fig. 1). These severe hyperextension deformities must be distinguished from the milder forms and the skin must be protected accordingly.[2]

A radiographic and ultrasonographic evaluation can be helpful in diagnosing the deformity; however, in most cases, no abnormal findings can be detected.

Most foals with mild digital hyperextension do not need treatment other than minimal attention and trimming of the feet. The animals should be carefully observed, and if the problem worsens, treatment should be promptly initiated. Moderate exercise is indicated; therefore, access to pasture is allowed. Excessive exercise is contraindicated because fatigue often aggravates the problem.

Swimming has been advocated as excellent controlled physiotherapy.[6] The animal is supported in a swimming pool or pond by one or two helpers or a rescue net (Fig. 2). The paddling action of the foal is performed against the resistance of the water and without placing weight on the limbs. The resultant increase in muscle tone brings about rapid improvement of symptoms.

Severe digital hyperextension problems must be treated immediately, because neglect soon leads to necrosis and traumatization of the skin in the palmar or plantar phalangeal region and jeopardizes treatment.

Application of glue-on shoes or similar devices with palmar or plantar extensions helps maintain the hoof sole on the ground[9] (Fig. 3). Application of a splint in combination with extension of the heel can help in the treatment. However, care has to be taken not to overprotect the flexor tendons and their associated muscles.

Light bandaging of the phalangeal region is indicated to minimize skin trauma. Splint bandages and casts incorporating the feet are contraindicated because they totally support the distal limb, leading to a further loss of tone of the already hypotonic flexor tendon units. Additionally, development of pressure sores on the delicate skin is a common untoward sequela.

Application of some padding between the elongated braces attached to the foot and the palmar or plantar aspect of the phalangeal region provides support and decreases the excessive hyperextension angle. Daily swimming and carefully dosed antiinflammatory drugs are indicated and should always be part of therapy.

Tenoplasty as a surgical management technique for severe digital hyperextension problems is currently not recommended.

Contractural Deformities

The characteristic stance of foals with contractural deformities makes the diagnosis easy in most instances (Fig. 4). The problem may be displayed in various degrees of severity and in several locations such as the distal interphalangeal joint, the metacarpophalangeal, or the carpal region (Fig. 5). Some foals are able to stand but buckle forward in that region; others with severe deformities are not able to stand at all.

The affected area is palpated and manipulated with the animal in both weight-bearing and non-weight-bearing positions. In most cases the only abnormality noted is the lack of mobility in the affected joint or joint region. An attempt should be made to correct the deformity manually. The resistance toward such an effort is a good indicator of the prognosis and can help in deciding whether to treat a foal. Palpation of the flexor tendons during manipulation is helpful in determining which structures are involved. Both the deep and superficial digital flexor tendons and even the suspensory ligament are often involved.[1]

If manual correction is easily obtained, the animal should certainly be treated and has a good prognosis to respond positively to splint or cast management. In foals whose deformities are not manually correctable, the decision to treat depends on the severity of the deformity and prevailing economics. As examples, treatment should be initiated in a foal with a mild contractural deformity of the distal interphalangeal joint that is unresponsive to manual correction, whereas treatment might not be indicated in a foal with a severe deformity in the carpal region.[10]

A radiographic evaluation can be helpful in diagnosing congenital contractural deformities to determine whether bony abnormalities are associated.

Analgesics

Most foals suffering from a contractural deformity benefit from the administration of nonsteroidal antiinflammatory drugs (NSAIDs), because the increased tension on the flexor tendons induced during ambulation is painful. Judicious use of these drugs is important to prevent the potentially detri-

Figure 2 (A) A 2-week-old Islandic pony is shown with marked digital hyperextension located in fetlocks of both forelimbs. The foal wears a rescue net. (B) The table was lowered into warm water so that the foal was immersed in it, protected by the rescue net, which was attached to a hoist. (C) The same foal 4 weeks later. There is some improvement, but the fetlock angles are still hyperextended. (Color version of figure is available online.)

mental side effects, including gastric ulcers and nephrotoxicity. Administration of phenylbutazone at 1.1 mg/kg of body weight IV once a day and concurrent treatment with ranitidine (6.6 mg/kg orally three times a day, or 1.5 mg/kg IV three times a day) as a gastric protectant has been proposed.[11] Omeprazole (ULCERGARD™/GASTROGARD™; Merial, Duluth, GA) at a dosage of 1-4 mg/kg q 24h is currently the most efficacious and convenient gastric ulcer prevention and treatment. Phenylbutazone plus cimetidine is another potentially useful combination of drugs to reduce pain in the treatment period.

Intravenous Oxytetracycline

Administration of oxytetracycline has gained in popularity as an initial treatment for congenital contractural deformities. A single dose of 3 g of oxytetracycline in 250 to 500 mL of physiologic saline is administered slowly by the intravenous route.[12] An in vitro study showed that oxytetracycline induced a dose-dependent inhibition of collagen gel contraction by equine myofibroblasts. Oxytetracycline also induced a dose-dependent decrease in matrix metalloproteinase 1 (MMP-1) mRNA expression by equine myofibroblasts.[13] Results of this study indicate that oxytetracycline inhibits tractional structuring of collagen fibrils by equine myofibroblasts through an MMP-1-mediated mechanism.[13] In doing so the developing ligaments and tendons become more susceptible to elongation during normal weight bearing, which results in correction of the deformity within 24 to 48 hours. The treatment may be repeated once or twice within the first weeks of life if necessary. No side effects have been mentioned, other than vital staining of the active osteons in the bone.

Mild cases of contractural deformities respond to this

Figure 3 (A) Top view on Dalric glue-on shoe. The heel extension is covered with padding. (B) The shoe is applied to a foot. (C) The foal in Fig. 1 with one Dalric glue-on shoe applied. There is an obvious visible difference. (Color version of figure is available online.)

treatment with complete correction. In more severe cases or, more likely, those with a different cause, the response is minimal and care must be taken to ensure that the foals are kept in a well-padded area with soft ground to prevent excessive wearing of hoof horn at the tip of the foot. If that is not possible, protection of the toes may be indicated. Addition of a splint bandage (see later discussion) can support correction.

In a comparative study, a single dose of 44 mg/kg oxytetracycline was administered intravenously to normal newborn foals and newborn foals suffering from flexural deformities.[14] This treatment resulted in a significant decrease of the metacarpophalangeal joint angle in both groups. Within 4 days after the injection the foals regained their pretreatment angle. Based on this observation, one report accorded no clinical value to the oxytetracycline treatment of flexural deformities.[11]

Toe Extensions

Application of a dorsal hoof extension, using acrylic alone or in combination with a lightweight foot plate, protects the toe from excessive wear and increases the tensile forces in the deep digital flexor tendons during ambulation. This probably helps in correcting the problem.

To help maintain these devices on the feet for a longer period of time, numerous holes, spread over the entire dorsal hoof wall, of approximately 2 mm in diameter and depth are drilled (Fig. 6A). The hoof acrylic used to achieve the dorsal extension is spread over the dorsal hoof wall and digitally worked into the holes to add stability to the device (see Fig. 6B). The acrylic, interdigitating with the dorsal hoof wall, counteracts the increased leverage forces at the toe extensions and prolongs their life. Additionally, filling in the space between the extension and the dorsal hoof wall decreases the risk of the foal's stepping on the extensions or stumbling over them.

These devices may be successfully applied in newborn foals with mild contractural deformities of the metacarpophalangeal joints, when the foal cannot bear weight without knuckling over. Extending the dorsal hoof wall adds the necessary elongation to compensate for the lack of extension in the phalangeal region and allows the foal to stand without knuckling. Once the foal is able to ambulate, correction of the deformity is usually achieved within 2 weeks, at which time the extensions typically become detached.

The toes must be protected from excessive wear as foals are allowed free exercise. A special half-round glue-on shoe has been developed for this purpose, with a toe extension built into its design.[15]

Splints and Casts

Splints and casts are effective for treating contractural deformities. Foals suffering from contractural deformities of the distal interphalangeal joint that are unresponsive to hoof ex-

Figure 4 A 1-day-old foal with a contractural deformity in both fore distal interphalangeal joints; the foal is visibly tippy-toeing. (Color version of figure is available online.)

tensions can be treated with half-limb casts, incorporating the feet. This treatment causes relaxation of the muscle-tendon units within a few (10-14) days, correcting the problem.[2,3]

Some authors prefer splints applied over casts because they can be worn for several hours followed by a period without splints.[16] When the tone has returned into the muscle-tendon units, the animal may exercise, possibly with some concomitant antiinflammatory drug therapy, and maintain the correction. Casts must be changed at least every 2 weeks to keep pace with the growth of the foal and prevent the formation of pressure sores.

Splints are preferably used in contractural deformities of the metacarpophalangeal and carpal region, especially in mild carpal contractural deformities. In these cases care is taken to avoid incorporation of the phalangeal region into the splint.[16] Splints must be well padded and changed every 3 to 5 days. It is important to use new, dry padding at each bandage change to minimize development of pressure sores.

Splints may be used in combination with intravenous oxytetracycline, especially in treatment of severe carpal contractural deformities. These foals are unable to rise and nurse and must be assisted many times daily.

Stretching of tendons and associated contracted soft-tissue structures (eg, joint capsules) is painful; therefore, administration of low doses of antiinflammatory drugs is necessary. It is advisable to prolong the application intervals to prevent overdosing the patient. The doses should be reduced from the calculated dose per kilogram of body weight regimen.

Surgical Management

Surgical intervention is rarely necessary with congenital contractural deformities. Surgical transection of the flexor carpi ulnaris and the ulnaris lateralis tendons at their insertion on the accessory carpal bone resulted in the correction of mild carpal deformities.[17,18] The surgery is performed under general anesthesia with the foal in lateral or, in cases of bilateral involvement, in dorsal recumbency. It is advisable to manipulate the limb immediately before surgery, while the foal is under anesthesia, to see if these tendons tighten when forceful carpal extension is applied. The tendons are easily identified and are transected through a small incision between the tendons. Routine aftercare is given to these patients.

Ruptured Common Digital Extensor Tendon

This relatively common congenital disorder has some pathognomonic features that simplify the diagnosis.[2,3,19] Afflicted foals display a characteristic swelling in the tendon sheath at the dorsolateral aspect of the carpus and may show a slightly bowlegged and over-in-the-knees stance. This stance is caused by the lack of support at the dorsolateral aspect of the carpus, which is normally conferred by the intact common digital extensor tendon. Therefore, it is not truly a contractural deformity, but it clinically appears as one. During walking, afflicted animals throw their forelimbs forward, extend them completely, and retract them slightly before contacting the ground. A foal with a ruptured common digital extensor tendon often knuckles at the metacarpophalangeal joint during walking and might buckle in the carpal region while standing. In severe cases the foal may not be able to stand straight without knuckling forward and may stand on the dorsal surfaces of the phalanges (Fig. 7A).

Incomplete ossification of the cuboidal carpal and tarsal

Figure 5 A newly born foal with a marked flexural deformity in both carpal regions.

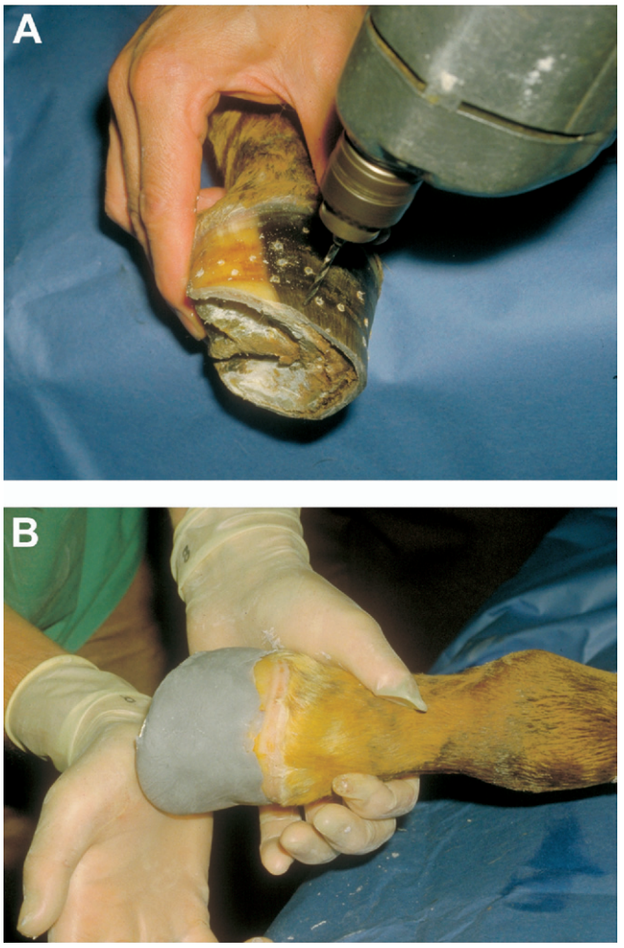

Figure 6 (A) Multiple 2-mm drill holes are prepared in the dorsal hoof wall of a foal with a contractural deformity in the distal interphalangeal joint. (B) The hoof acrylic is worked into the holes and the toe dorsally extended for approximately 1 cm. (Color version of figure is available online.)

bones is usually diagnosed concomitantly in foals afflicted with ruptured common digital extensor tendons.

Foals with ruptured common digital extensor tendons are best confined to a box stall, because they tend to stumble frequently. Within a few weeks, locomotion normalizes and more exercise can be allowed.

Application of a well-padded splint bandage is the treatment of choice[19] (see Fig. 7B). The use of a thermoplastic splinting material (Plastazote; Smith & Nephew, Hull, England) in combination with a polyvinylchloride pipe splint has delivered excellent results. These devices maintain a normal limb axis, which allows ossification of the often dysmature carpal bones to proceed under orthogonal loading conditions. Additionally, pressure exerted over the distended tendon sheath of the common digital extensor tendon in the carpal region decreases swelling.

The splint bandage is changed every 3 to 5 days over a period of 2 to 4 weeks. During this time, stall rest is indicated. Once the splint is removed, the bandage is maintained for an additional 3 to 4 weeks. Subsequently, the bandage is removed for a day. Dependent on the speed of return of the swelling a bandage is reapplied for some time. Treatment is adapted to the response of the patient. In some cases, shorter intervals are successful (see Fig. 7C).

Aspiration of the synovial fluid from the tendon sheath is discouraged because of the risk of infection. Continuous external pressure quickly induces absorption of the excess fluid.

It is generally accepted that ruptured common digital extensor tendons should not be treated surgically because of the good prognosis and success of splint application.[19] The risk of complications secondary to surgery outweighs any improvement in the prognosis.

Acquired Deformities

For the development of acquired flexural deformities there exist several pathways. Some authors assess these deformities as being part of the developmental orthopedic disease (DOD) complex, which also includes angular limb deformities, osteochondrosis, physitis, and cervical vertebral malarticulations or malformations.[8]

Rapid longitudinal bone growth induces increased tension in the flexor tendons. Earlier it was postulated that the bone outgrows the potential of the tendons to passively lengthen, mainly because of the presence of the accessory ligaments to the deep and superficial digital flexor tendons, respectively.[1,2]

The rate of bone growth is determined by genetics and nutrition. Foals can be overfed either by heavily lactating mares or by excessive supplementation with concentrates.[20] It has been shown that an abrupt change from inadequate nutrition, both in quality and quantity, to abundant nutrition also can induce the problem in yearlings.[21,22]

Kidd and Barr[11] have stated that longitudinal bone growth is insufficient at any age to create a relative shortening of the flexor tendons. They postulated that rapid growth increased tension within the flexor tendons and that this could induce pain and a subsequent reflex contracture of the muscles involved, ultimately leading to the development of contractural deformities. Contractural deformities often have an acute onset of 24 to 48 hours, which also supports this theory. While muscle contractions can develop in such a short period, bone lengthening would take longer.

A study of skeletally normal foals revealed that most of the cells in the deep digital flexor tendon and its accessory ligament are myofibroblasts.[23] These cells have contractile ability and therefore might play a role in the development of contractural deformities.

This leads to pain as the primary inciting factor associated with acquired contractural deformities. Any painful condition can be responsible for the flexion withdrawal reflex and the resultant muscle contraction, leading to an altered stance.

Acquired contractural deformities are seen more often than acquired hyperextension deformities. Continuous overload of certain limbs can, in selected cases, induce hyperextension deformities. Such problems can also be encountered after ruptures of flexor tendons.

Distal Interphalangeal Joint

Early signs of impending contractural deformity of the distal interphalangeal joint are a steeper dorsal hoof wall angle and

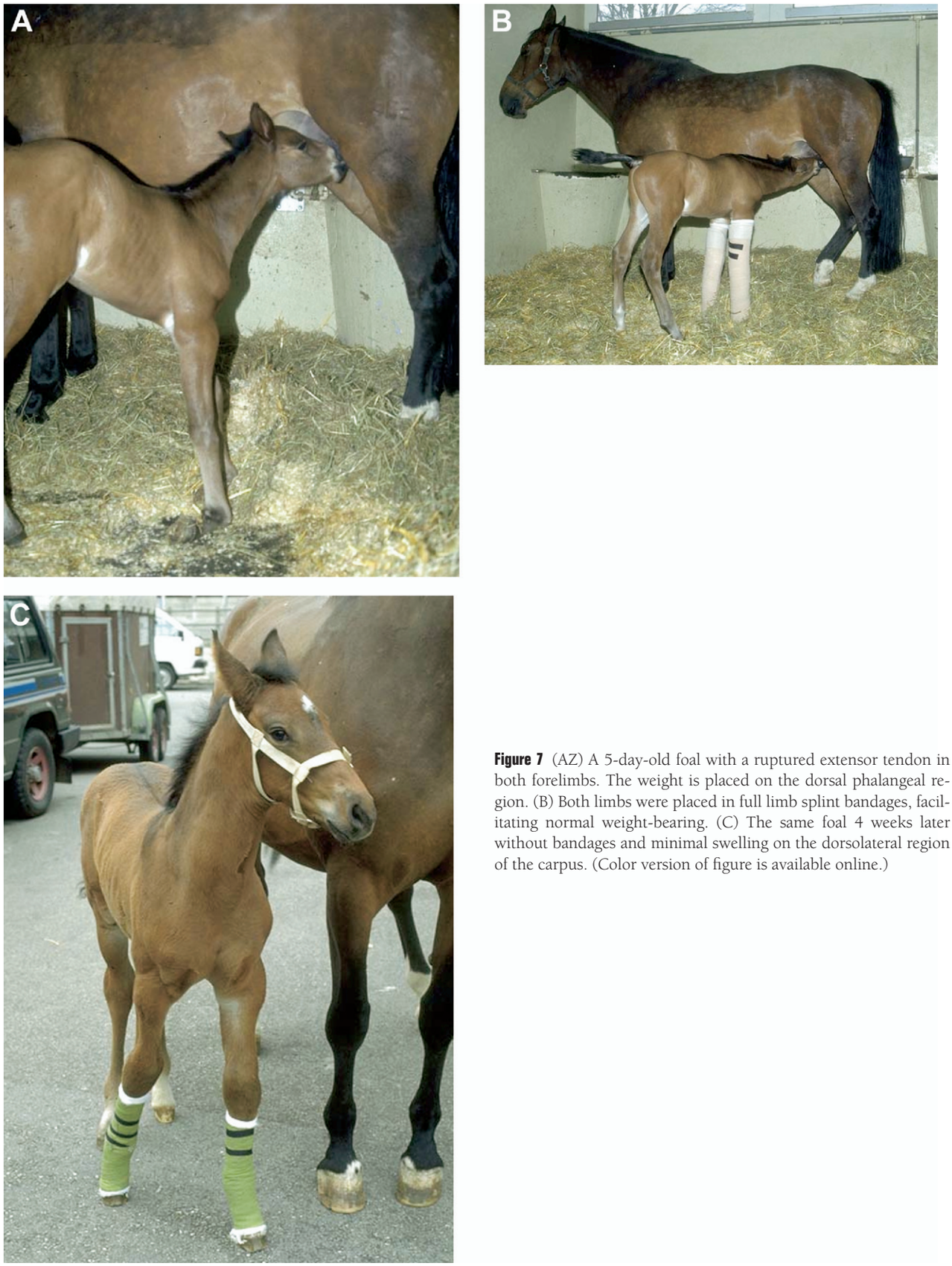

Figure 7 (AZ) A 5-day-old foal with a ruptured extensor tendon in both forelimbs. The weight is placed on the dorsal phalangeal region. (B) Both limbs were placed in full limb splint bandages, facilitating normal weight-bearing. (C) The same foal 4 weeks later without bandages and minimal swelling on the dorsolateral region of the carpus. (Color version of figure is available online.)

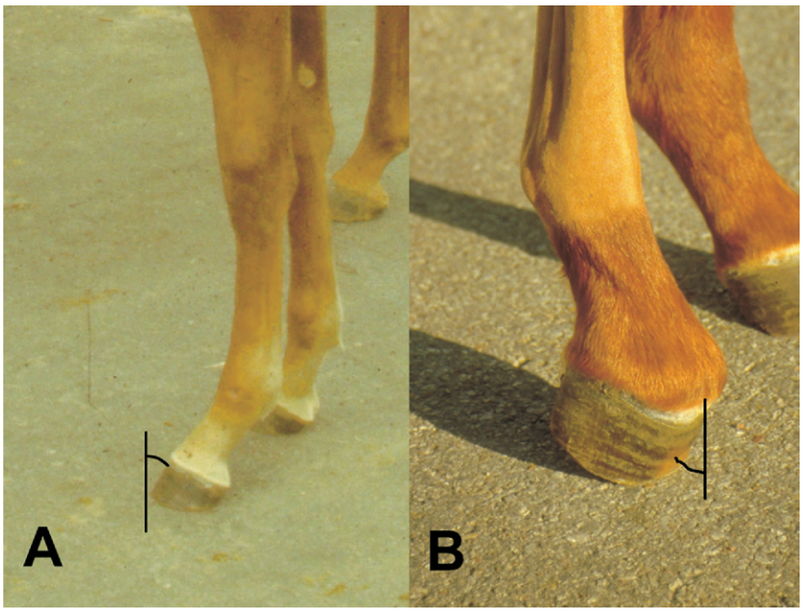

Figure 8 (A) Stage I contractural deformity in the left forefoot of a 7-month-old foal, identified by the broken phalangeal axis. The dorsal hoof wall is approaching the vertical line. (B) Stage II contractural deformity in the right foot of 6-month-old foal. The toe moves away from the vertical axis drawn. (Color version of figure is available online.)

a relatively short toe. With time, the typically boxy foot develops in which the dorsal hoof wall and the heel are practically of the same length. As the heel grows, flexion of the distal interphalangeal joint and hyperextension of the metacarpophalangeal joint increase.

For diagnostic, therapeutic, and prognostic purposes, a classification of deformities has been proposed[24] (Fig. 8). A stage I deformity is present when the angle described by the dorsal hoof wall and the sole is less than 90°; in stage II contracture, the dorsal hoof axis passes beyond the vertical. The longer the condition is neglected, the worse the deformity becomes.

Nutrition

Balanced nutrition especially of the minerals and trace minerals is important for normal development of the skeleton and enchondral ossification. Foals still suckling should be weaned early, especially if they develop an angular limb deformity.[11]

Physiotherapy

It is important that afflicted foals exercise frequently. Extensive exercise can stretch the tendons and correct the problem; however, it is important that the toe region is protected to prevent excessive wear and possible development of a septic process.

Analgesics

Passive stretching of shortened or relatively shortened tendons is a painful process. To aid the foal in standing and moving around, nonsteroidal antiinflammatory drugs are given at low doses. Foals with painful limbs tend to lie down a lot, which can aggravate the contractural problem.

Toe Extensions

Application of toe extensions or glue-on rubber shoes are effective for the treatment of flexural deformities of the distal interphalangeal joint.[15] The purpose of this treatment is protection of the toe and prevention of excessive wear in that region. As described above, the toe extension moves the weight-bearing surface of the foot farther forward, allowing a later breakover and greater tensile stress on the palmar soft tissue structures of the phalangeal region.

Simple trimming of the excess heel of a club-footed foal is contraindicated as the only treatment, because it reduces the weight-bearing surface area and causes more rapid wearing of the tip of the toe. In most cases, a club foot develops initially because of the greater wear at the toe and lack of wear at the heel, not more rapid growth of the heel. Trimming of the heel combined with application of a toe extension and protection, however, can be an effective treatment.

Cast Application

Cast application in foals causes temporary weakening of the tendons. The distal limbs of afflicted foals may be covered with a fiberglass cast that incorporates the feet for 10 days to a maximum of 14 days. After cast removal, the weakened tendons allow correction of the problem. Despite the fact that the weakening persists for only a few days, the author has achieved permanent correction of the problem with this technique. However, because of the potential complications associated with this type of treatment, cast application is rarely used.

Desmotomy of the Accessory (Check) Ligament of the Deep Digital Flexor Tendon

The treatment of choice for stage I contractural deformities is desmotomy of the accessory ligament of the deep digital

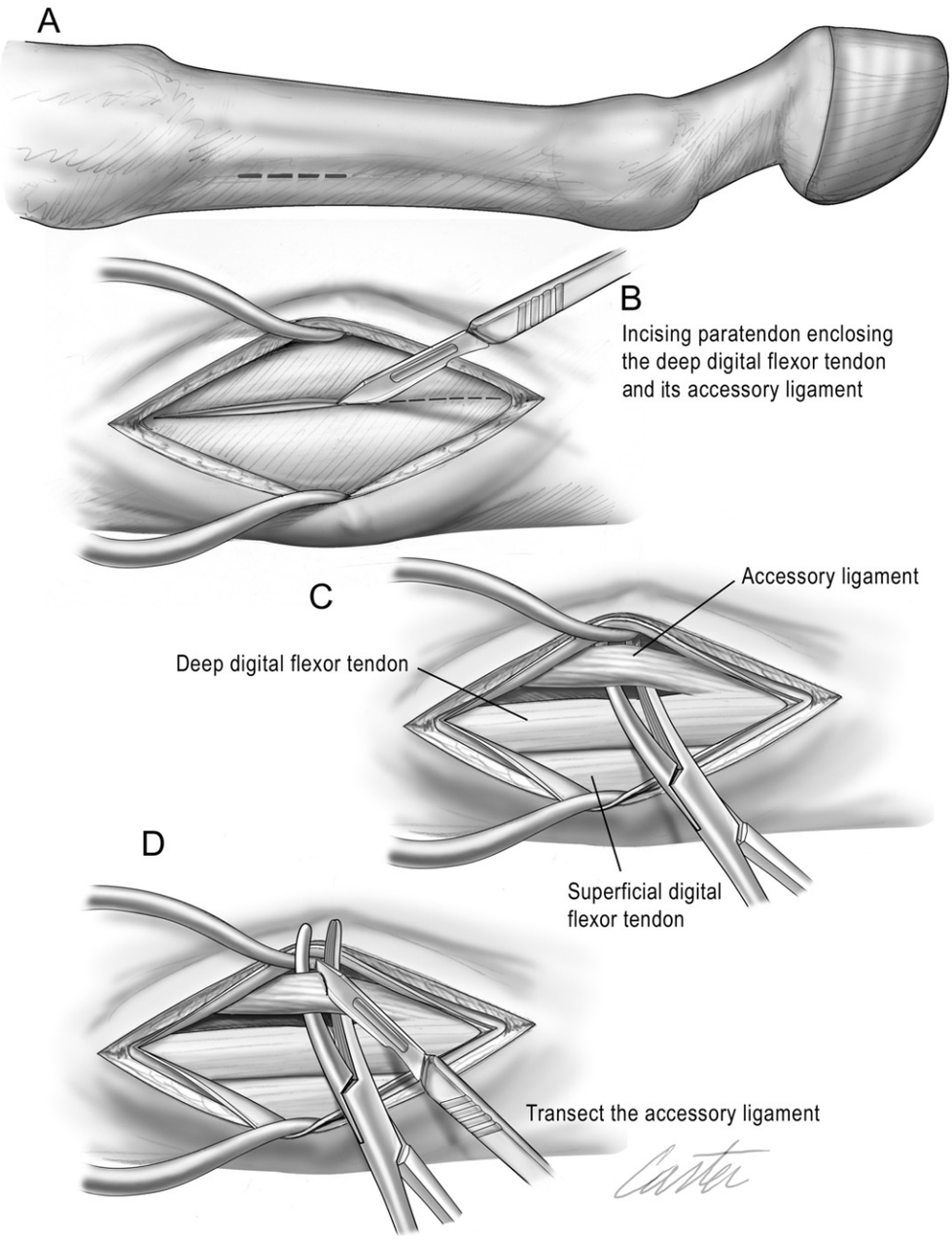

Figure 9 Surgical technique of desmotomy of the accessory ligament of the deep digital flexor tendon (inferior check ligament desmotomy). (A) Location of the surgical site on the medial, or in most cases the lateral, side of the limb. (B) The paratenon enclosing the deep flexor tendon and the accessory ligament is incised. (C) The accessory ligament is isolated along its division plane with the deep digital flexor tendon. (D) The isolated and elevated accessory ligament is transected.

flexor tendon (inferior or subcarpal check ligament).[2,3,24-27] The ligament is usually approached from the lateral aspect of the limb because of the greater ease in its isolation for transection and the better cosmetic result.

A 5-cm skin incision, centered at the junction between the proximal and middle third of the McIII, is made over the deep digital flexor tendon (Fig. 9A). The subcutaneous tissues are separated and the tendinous structures identified (see Fig. 9B). With the medial approach, the neurovascular bundle overlying the deep digital flexor tendon and its accessory ligament are identified and reflected away from deeper structures. Palpation of the paratenon surrounding the deep digital flexor tendon and its accessory ligament allows separation between the two structures.

A curved hemostatic forceps is introduced and advanced following the slightly curved surface of the tendon to the opposite side, where the forceps is spread and turned (see Fig. 9C). The accessory ligament of the deep digital flexor tendon lying dorsal to the tendon is elevated to the level of the skin incision (see Fig. 9D). Manipulation of the foot in a

dorsal direction tightens the ligament and ensures the isolation of the correct structure. Once the ligament is positively identified, it is sharply transected with a scalpel blade. Dorsal rotation of the distal interphalangeal joint produces a 1-cm gap between the transected ends of the ligament. The gap is inspected and palpated, and any remaining fiber strands of the accessory ligament are transected.

The paratenon, subcutaneous tissues, and skin are closed using 2-0 or 3-0 absorbable suture materials in a continuous pattern. Intradermal placement of the skin suture is advised for a better cosmetic result. Postoperatively, a pressure bandage is applied and maintained for 2 to 3 weeks and changed at 3- to 4-day intervals.

Correction of the deformity is usually observed immediately. In some cases, however, it takes a few days until correction is complete. Occasionally, application of a toe protection or extension is needed. Young foals and those without longstanding contracture are allowed controlled exercise within 3 to 6 days after the surgery. Free pasture exercise is encouraged after 2 weeks. In older foals and those with chronic or severe contracture, limiting exercise for a period of months might prevent excessive fibroplasia at the surgery site. To relieve potential pain, nonsteroidal antiinflammatory agents may be administered at low doses.

A minimally invasive ultrasonographically guided technique was developed some time ago. This technique can be performed in standing horses.[28]

Long-term follow-up of Standardbred foals treated with a desmotomy of the accessory ligament of the deep digital flexor tendon revealed that young foals (younger than 8 months at the time of surgery) could reach their athletic potential.[29] No foals treated after 8 months of age had a favorable outcome.

Tenotomy of the Deep Digital Flexor Tendon

Severe stage II contractural deformities (Fig. 10A) do not correct after desmotomy of the accessory ligament of the deep digital flexor tendon. Tenotomy of the deep digital flexor tendon can be used successfully for correction.[30] Initially, such a tenotomy had been looked at as a salvage procedure; however, several animals have developed into sound riding horses.

Two main sites for the surgical procedure have been proposed. The distal approach centers at the palmar and median aspect of the pastern joint region and enters through the tendon sheath just distal to the bifurcation of the superficial digital flexor tendon.[30] The deep digital flexor tendon is identified, exteriorized, and transected with a scalpel blade. Immediate retraction of the proximal stump into the tendon sheath is noted. The tendon sheath may[27] or may not[31] be sutured using routine technique in addition to the subcutaneous tissue and the skin.

While the animal is under anesthesia, the feet are trimmed to a shape as normal as possible. Postoperative correction is often immediate and can be associated with substantial pain. Administration of adequate doses of nonsteroidal antiinflammatory agents is therefore demanded.

Because of the long time it takes for a stage II contractural deformity to develop, the soft tissue structures, such as joint capsule, ligaments, and periarticular tissues at the palmar aspect of the phalanges, are significantly contracted. Transection of the deep digital flexor tendon at the level of the proximal interphalangeal joint does not result in a marked elevation of the toe during weight bearing, as it does after rupture of this tendon in the region of the navicular bone (see

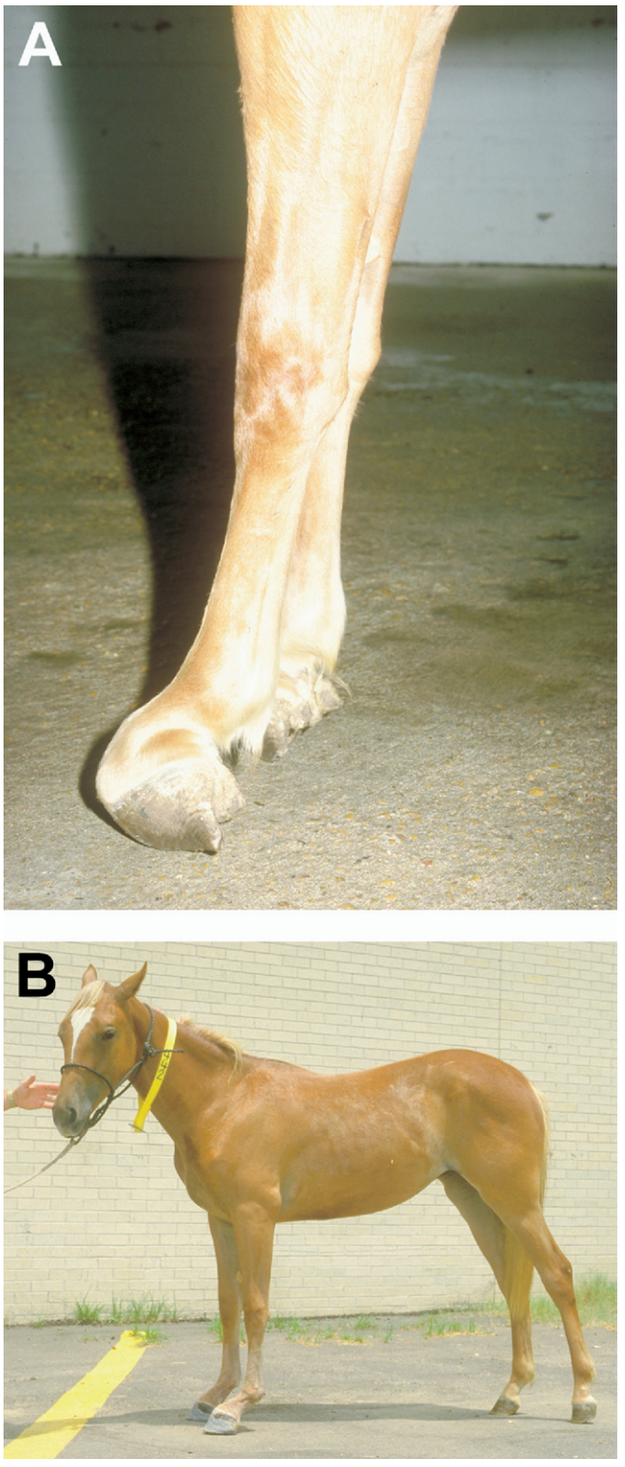

Figure 10 (A) The forefeet of a 7-month-old foal with stage II contractural deformity of the coronopedal joint. Note the abnormal configuration and wear of the feet. (B) The same foal 2 days after surgery. The deep digital flexor tendon was transected at the pastern level in both feet. Hoof acrylic was applied to the feet for protection. The animal has an almost normal stance. (Color version of figure is available online.)

Figure 11 A yearling foal with marked flexural deformity of both metacarpophalangeal joints. (Color version of figure is available online.)

Fig. 10B). Nevertheless, in selected cases, application of a shoe with a heel extension is necessary.

Transection of the deep digital flexor tendon at the midmetacarpal level has been advocated.[31-33] The procedure is performed through a medial or lateral approach. The advantages of this approach is the greater distance from the feet and the fact that a tendon sheath is not invaded and the possibility to perform the surgery on the sedated, locally anesthetized horse in standing position. Additionally, the procedure is easier to perform at the midmetacarpal level. However, scarring associated with marked disfigurement of the tenotomy site can be an undesirable sequela. Postoperative management is identical to that used with the other technique.

Metacarpophalangeal Joint

Acquired contractural deformities of the metacarpophalangeal joint are initially characterized by a straight metacarpophalangeal angle. Palpation of the flexor tendons allows determination of which structure is tightest: the deep flexor tendon unit, the superficial flexor tendon unit, or the suspensory ligament. Application of pressure to the dorsal joint region in a palmar direction tenses the tendons. This diagnostic test is important to help select treatment.

Knuckling over in the metacarpophalangeal region is seen in more severe cases in which treatment has been neglected for a long time (Fig. 11). It is important to diagnose a contractural deformity as early as possible, and promoting client awareness can be helpful in this regard.

Nutrition

As with contractural deformities of the distal interphalangeal joint, the nutrition intake of the patient should be corrected first. Foals being conditioned for yearling sales should be checked carefully for early signs of contractural deformities of the metacarpophalangeal joint.

Analgesics

Passive stretching of shortened or relatively shortened tendons is a painful process. Nonsteroidal antiinflammatory agents are administered or given frequently to manage the pain involved in trying to stretch the tendons and their associated accessory ligaments and to overcome the reflex muscle contracture. As mentioned earlier, foals with painful limbs tend to lie down a lot, which can aggravate the contractural problem.

Corrective Shoeing

Corrective shoeing can eliminate contractural deformities of the metacarpophalangeal joint. Raising the heel with wedge pads results in a more acute angle of the metacarpophalangeal joint as a result of partial relaxation of the deep digital flexor tendon.[3,31] Some authors have questioned the effectiveness of such treatment, but clinically, an improvement is possible.[5] Toe extensions have been advocated and have proved very effective, especially when the problem was diagnosed early.[2,3,33] As the animal walks, breakover occurs later, and through this, greater tensile stress is exerted on the flexor tendons.

Splints

Splint application can bring about some correction, especially in early recognized cases. Care must be taken to prevent development of pressure sores. Exercise is an important type of therapy, but it should be performed in a controlled manner.[33] Excessive exercise leads to fatigue, which should be avoided.

Desmotomy of the Accessory (Check) Ligament of the Deep Digital Flexor Tendon

If the deep digital flexor tendon was tighter during palpation and manipulation, its accessory ligament should be transected using the technique described above.[34] Application of a preshaped polyvinylchloride half-pipe splint is necessary for 2 to 3 weeks to maintain the metacarpophalangeal angle in the normal range.

Desmotomy of the Accessory (Check) Ligament of the Superficial Digital Flexor Tendon

Transection of the accessory ligament of the superficial digital flexor tendon should be performed when this tendon was tighter during manipulation.[3,35] The surgical landmarks for both approaches are the same and consist of the medial distal physis of the radius, the proximal aspect of the chestnut, and the cephalic vein. An approximately 10-cm skin incision is performed between the chestnut and the distal radial physis craniad to the cephalic vein[36] (Fig. 12A). The subcutaneous tissue is bluntly separated, and communicating branches to the cephalic vein are isolated, double ligated, and transected between ligatures.

The accessory ligament is approached through the sheath of the flexor carpi radialis tendon[37,38] (see Fig. 12B). After reflecting the flexor carpi radialis tendon in the sheath with a self-retaining retractor, the craniolateral wall and accessory ligament are identified (see Fig. 12C). A curved Kelly forceps

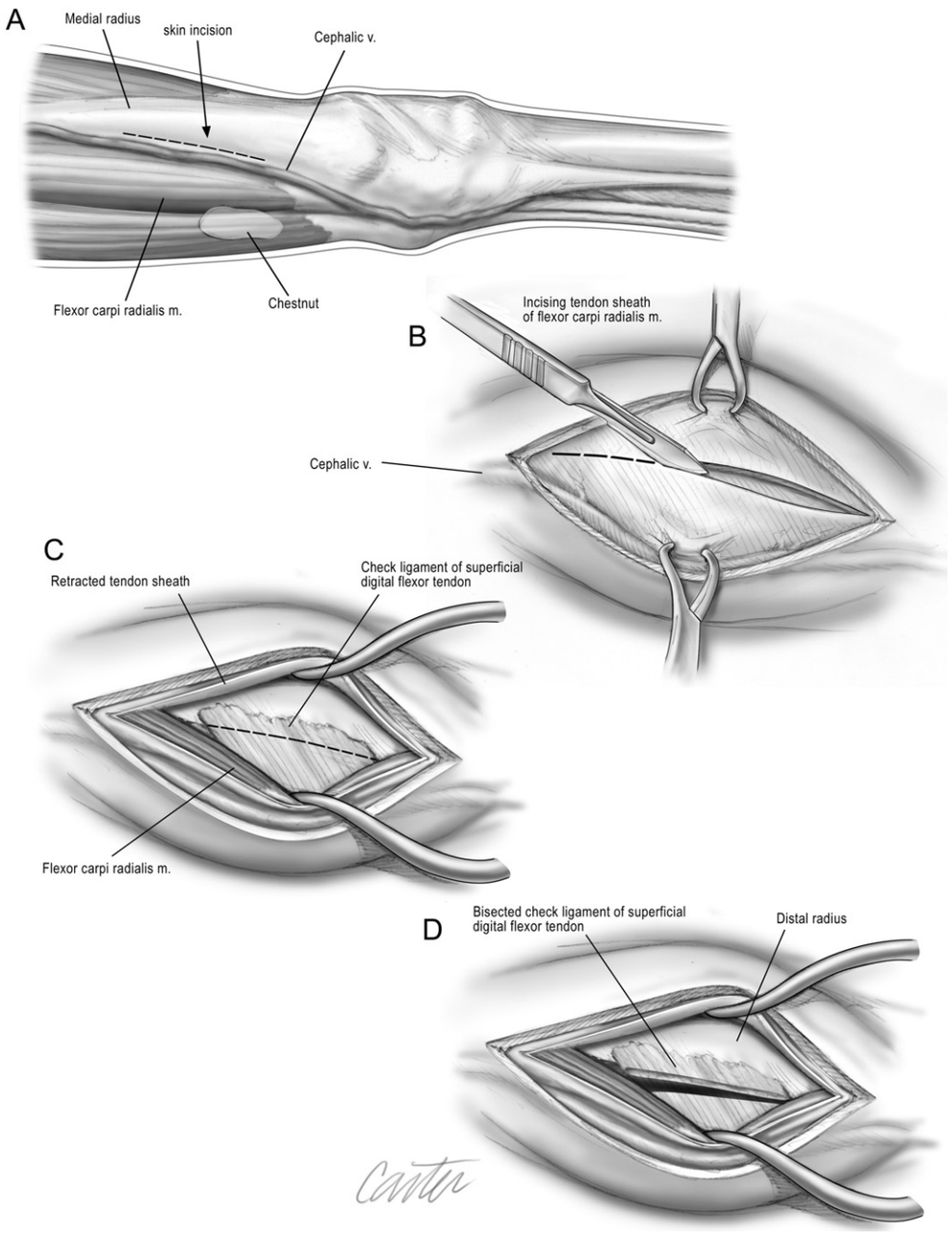

Figure 12 Surgical technique of accessory ligament desmotomy of the superficial digital flexor tendon (superior check ligament desmotomy). (A) Location of the surgical site relative to the anatomic landmarks: cephalic vein, distal radial physis, and chestnut. (B) The tendon sheath of the flexor carpi radialis muscle is incised. (C) The flexor carpi radialis tendon is retracted, allowing visualization of the craniolateral tendon sheath wall. The site of the desmotomy incision is marked with a dotted line over the accessory ligament, which is at that location part of the craniolateral tendon sheath wall. (D) The accessory ligament desmotomy is completed, allowing digital access to the radial head of the deep digital flexor muscle.

is placed under the distal border and spread. Transection of the ligament is then performed in a proximal direction (see Fig. 10D). Care is taken to avoid injury to the large nutrient artery of the superficial flexor tendon, which enters along the proximal border of the accessory ligament. After transection of the ligament the radial head of the deep digital flexor muscle appears and the carpal sheath becomes visible. Inadvertent incision of the carpal sheath is of no serious consequence. Closure of the tendon sheath is performed using a continuous suture pattern with 2-0 or 3-0 synthetic absorbable material. The rest of the closure is routine. Lengthening of the superficial digital flexor musculotendinous unit after desmotomy of the accessory ligament of the superficial digital flexor tendon can be associated with increased strain on the suspensory ligament.[39]

Postoperatively, a sterile pressure bandage is applied and maintained for 2 to 3 weeks. The bandage is changed at 3- to 4-day intervals.

In severe cases, the accessory ligaments of both the deep and the superficial digital flexor tendons are transected.[26] As an additional alternative procedure, desmotomy of the medial and lateral branch of the suspensory ligament may be performed for salvage purposes in persistent cases. However, subluxation of the proximal interphalangeal joint is to be expected. A stab incision is performed directly over the suspensory branch, the subcutaneous tissues are separated with a Kelly forceps, and a curved tenotome is introduced. By applying pressure with a sawing motion, the previously undermined suspensory branch is transected. Care should be taken to avoid inadvertent injury to the palmar artery and vein and the metacarpophalangeal joint capsule. The skin is closed using a few simple interrupted sutures. The same procedure is performed on the opposite side of the limb.

Severe contractural deformities following prolonged nonweight-bearing lameness do not respond to desmotomy of either of the two accessory ligaments. Such cases should be treated either with a tenoplasty as the lengthening procedure in both flexor tendons, followed by long-term cast application, or with an osteotomy in conjunction with a fetlock arthrodesis.

Complications

Splint-associated pressure sores are the most often encountered complication. To avoid such complications, padding is placed around sites of predilection. Once necrosis is present, the local pressure must be released in that area. Application of a donut-shaped pad around the periphery of the lesion can assist in that effort. Alternate application or temporary removal of the splint may be attempted. Daily topical wound care is necessary, especially in the initial period.

Persistent hematoma formation, especially at the site of transection of the accessory ligament of the superficial flexor tendon, wound dehiscence, and infections are the most common complications encountered after surgical treatment. Whenever fever, leukocytosis, warmth at the surgery site, or increased pain are noted, an evaluation of the incision should be made and the necessary steps taken immediately. For additional information on wound dehiscence, please review the literature.[10]

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