Chronic Achilles tendon rupture augmented by transposition of the fibularis brevis and fibularis longus muscles

K. A. Diserens[1], C. Venzin[2]

[1] Cabinet vétérinaire du Dr. Gmür, Lausanne, Switzerland, [2] Clinic of small animal surgery, Vetsuisse-Faculty, University of Zürich, Switzerland

DOI 10.17236/sat00035

Received: 24.11.2014
Accepted: 18.06.2015

Summary

A 1 year and 8 months old castrated male Pyrenean mountain dog was presented with an Achilles tendon rupture at least 5 weeks old. The defect between the two tendon ends was 2 cm in full extension of the tarsal joint. A new technique was successfully applied; a transposition and tenodesis of the fibularis brevis and fibularis longus muscles, combined with a 3 loop pulley suture and a tensor fascia lata graft. A transarticular external fixator was used for the first 3.5 weeks after surgery and a splint for the two following weeks. A 3 years follow-up shows the dog walking without any lameness.

Keywords: dog, chronic Achilles tendon rupture, tendon transposition, fibularis brevis muscle, fibularis longus muscle

Verstärkung einer chronischen Achillessehneruptur durch Transpositionen vom M. fibularis brevis and M. fibularis longus

Ein 1 Jahr und 8 Monate alter, kastrierter Pyrenäen Hund wurde mit einer chronischen (>5 Wochen) Achillessehnenruptur vorgestellt. Der Defekt zwischen den beiden Sehnenstümpfen betrug bei voller Extension 2 cm. In dieser Publikation wird eine neue Technik zur Stabilisierung der Achillessehne vorgestellt. Dabei wird eine Sehnentransposition des M. fibularis brevis und M. longus, beschrieben, um die Achillessehne zu entlasten. Davor wurde die Achillessehne mit einer "3 loop pulley" vernäht und mit einem Faszien-Graft verstärkt. Postoperativ wurde die Sehne durch einen temporären transartikulären externen Fixateur und einem Schienenverband entlastet. Der Hund konnte über 3 Jahre verfolgt werden und blieb während der ganzen Zeit.

Schlüsselwörter: Hund, chronische Achillessehnenruptur, Sehnentransposition, Muskulus fibularis brevis, Muskulus fibularis longus

Introduction

The Achilles tendon rupture (ATR) is a well-described phenomenon in the veterinary literature. There are three types of ATR: complete rupture, partial rupture, and tendinosis or peritendinitis (Fahie, 2005). A further differentiation is made between acute and chronic ruptures (King and Jerram, 2003; Fahie, 2005; Spinella et al., 2010). Many studies have examined the healing process within the tendon and the best suture pattern to repair the rupture (Gelberman et al., 1999; Moores et al., 2004; Moores et al., 2004; Pajala et al., 2009). Some studies describe how to augment the tendon repair with a fascia lata graft (FLG) (Demirkan et al., 2004; Pajala et al., 2009), muscle flaps (Blatzer and Rist, 2009), porcine submucosa patches (Badylak et al., 1995; Gilbert et al., 2007), or a polypropylene mesh (Gall et al., 2009; Spinella et al., 2010). However, few studies describe the repair of an ATR with a defect. Three different techniques are described in the veterinary literature: the use of a polypropylene mesh (Gall et al., 2009; Spinella et al., 2010), the use of an FLG (Demirkan et al., 2004), or tendon transposition to reconstruct the tendon (Aron, 1990; Sivacolundhu et al., 2001). Here, we describe a new technique for repairing a chronic ATR with a defect. The technique involved performing a tenodesis of the fibularis brevis muscle (FBM) and the fibularis longus muscle (FLM) to the calcaneus. A 3-loop pulley (3LP) suture was placed between the proximal and distal ends of the Achilles tendon (AT), which had a 2 cm defect, and an FLG was placed around the tendon suture. These measures transferred part of the force from the AT suture to the FLM and FBM.

Case history

A castrated male Pyrenean mountain dog aged 1 year and 8 months and weighing 48 kg was presented to our Clinic. The dog had a plantigrade stance and was unable to bear weight on the left hind limb. Although the AT was not painful on palpation, there was a localised swelling about 3–6 cm proximal to the calcaneus. The dog had previously undergone surgery at an animal shelter in Spain to repair an ATR of unknown etiology. The technique used for that repair involved a tendon anastomosis supported by a 9-hole, 2.7 mm stainless steel bone plate (316L) placed caudal to the AT and sutured to it. The tendon was immobilised using a transarticular external fixator (TEF), although the duration of use was unknown. The dog was then brought to Switzerland (5 weeks before presentation). The referring veterinarian described a plantigrade gait, with local non-painful swelling of the AT. A splint bandage was applied for 3 weeks followed by a modified Roberts Jones bandage for a further 2 weeks. As the dog's condition did not improve, it was referred to the Clinic of small animal surgery at the Vetsuisse Faculty of Zurich. Radiographs (Fig. 1) performed on the day of presentation showed new bone formation, soft tissue swelling on the calcaneus at the AT insertion, and osteophytes on the cranial and dorsal aspect of the talus, calcaneus and distal tibia, which were indicative of chronic injury. The 9-hole stainless steel plate over the AT was apparent on the radiographs.

Figure 1: Preoperative radiographs (1A, medial-lateral; 1B, cranio-caudal) of the tarsal joint. The bone reaction and soft tissue swelling at the calcaneus indicate the chronicity of the injury. The 9-hole, 2.7 mm stainless steel bone plate (316L) and the hole in the calcaneus were placed during a previous operation in Spain.

Surgical procedure

The dog was anaesthetized and placed in a lateral recumbent position. A lateral surgical approach to the left AT was performed, extending from the middle of the tibia to the metatarsal bones. The fibrotic tissue, which had filled the defect within the ATR, was surgically debrided and the 9-hole plate removed and submitted for bacteriological culture. Once the tendon ends were debrided with the tarsus and knee in full extension, a 2 cm gap was revealed. Thus, proper apposition of the AT ends was not possible. Therefore, the FB and FL tendons were prepared and used to augment the AT. The distal FB tendon was detached from its insertion on the proximal lateral aspect of the fifth metatarsal bone and separated in a proximal direction. The distal FBM tendon was pulled in a retrograde direction to release it from the long collateral fibularis ligament. The FL tendon was then prepared and cut just proximal to its subdivision to the metatarsal bones. A 2.5 mm hole was drilled from the dorsal proximal aspect of the calcaneus to the plantar lateral surface of the calcaneus and the FB muscle tendon was passed through the hole (in a dorsal to plantar direction) with the help of a polypropylene (USP 2-0) stay suture. A parallel hole was drilled 1 cm proximal to the first one and the procedure was repeated using the FL muscle tendon. The end of the FB muscle tendon was fixed to itself and to the soft tissue surrounding the calcaneus using seven interrupted sutures (polypropylene, USP 3-0). The end of the FL tendon was rotated distally and sutured to the soft tissue beside the lateral aspect of the calcaneus (Fig. 2) using 11 interrupted sutures (polypropylene, USP 3-0). These sutures were inserted while the tarsal joint was in extension. A 3LP suture (polypropylene, USP 2-0) was then used to suture the AT ends. A defect of 2 cm remained when the tarsal joint was in maximal extension. Therefore, section of the FLG (8 × 4 cm) was harvested from the lateral aspect of the distal thigh. The donor site was closed using a 3-layer suture. The graft was then sutured (polydioxanone, USP 3-0) around the tendon defect, ensuring that it extended to the distal end of the gastrocnemius muscle and to the insertion of the AT (Fig. 3). At this point the tarsus could not be flexed while the knee was extended. A modified type II TEF was used to immobilise the tarsal joint in extension. Three full pins (two proximal 3.2 mm centre threaded pins and one distal 3.0 mm centre threaded pin) and two half pins (2.4 mm) were connected to an IMEX® TEF using a routine procedure (Fig. 4).

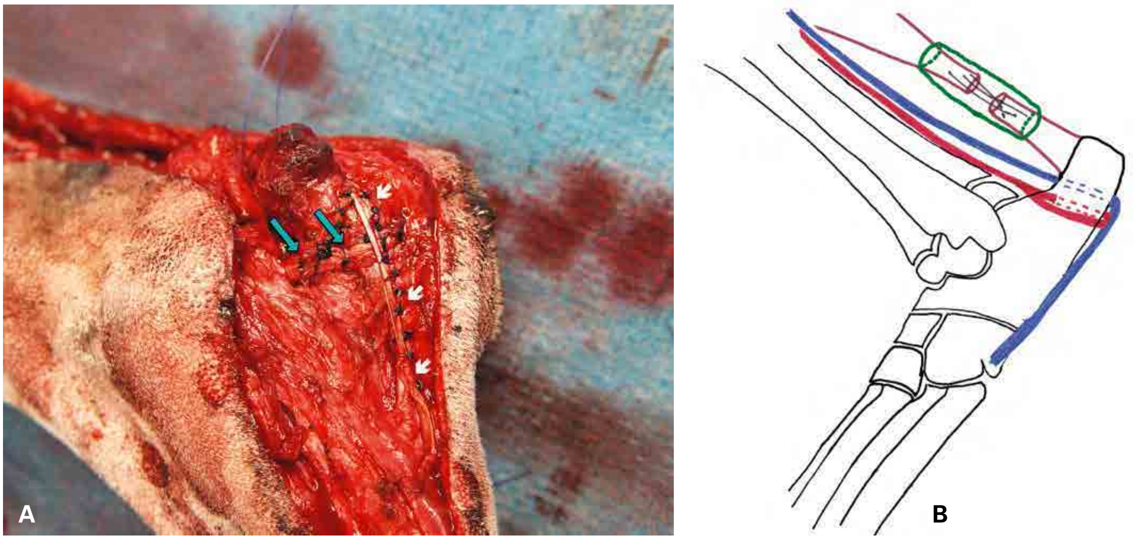

Figure 2: Intraoperative picture (A) of the fibularis brevis tendon (blue arrow), which was rotated dorsally and sutured to itself, and the fibularis longus tendon (white arrow), which was rotated distally and sutured to the soft tissue beside the lateral calcaneus. Illustration (B) showing the fibularis brevis tendon (red), which was rotated dorsally and sutured to itself, and the fibularis longus tendon (blue), which was rotated distally and sutured to the soft tissue beside the lateral calcaneus. The fascia lata graft (green) augments the 3-loop pulley suture.

Post-operative care

Post-operative analgesia comprised caprofen (Rimadyl®, Pfizer) at a dose of 4 mg/kg daily for 7 days, methadone (Methadone Streuli®, Sintetica) at 2 mcg/kg every 4 hours for the first 24 hours, and a Fentanyl (Durogesic®, Janssen Cilag) patch for 5 days. Enrofloxacin (5 mg/kg; Baytril®, Bayer) was given once daily for 4 days and discontinued when the bacterial cultures came back negative.

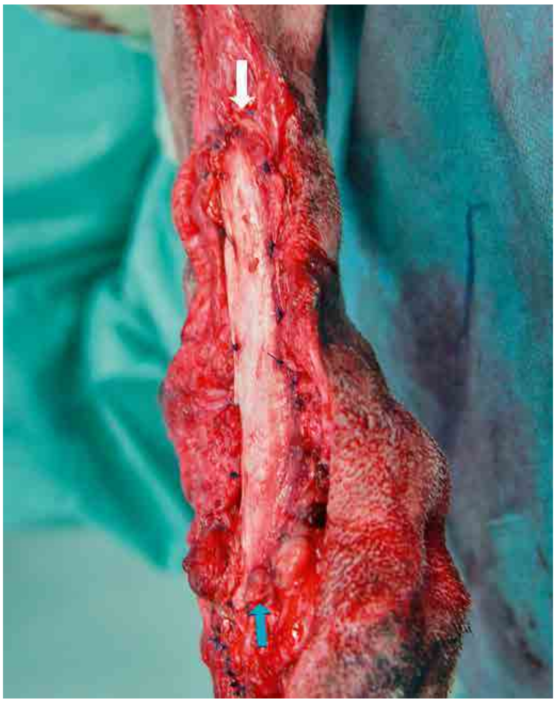

Figure 3: The fascia lata graft was placed around the 3-loop pulley and sutured around the tendon defect with simple interrupted sutures (polydioxanone 3-0). There was a 2 cm overlap at the distal end of the gastrocnemius muscle (white arrow) and at the insertion of the Achilles tendon (blue arrow).

Follow-up

On the day after the surgery, the dog was released from the hospital. He was able to put some weight on the left hind limb at this point. The bandage was changed weekly by the referring veterinarian. The dog's owner and the referring veterinarian observed an improvement in its condition during the first post-operative weeks. However, 3.5 weeks after surgery, the dog showed acute lameness in the operated limb. The two distal half pins had broken and therefore the TEF was removed. Clinical examination under sedation revealed that the repair was still intact; however, only light flexion of the tarsus was possible with an extended stifle. Thus, a modified Robert Jones with a splint was placed on the limb for a further 2 weeks and the bandage changed weekly. When the splint was removed, the dog was able to walk, albeit with a lameness grade of 3 out of 5. The dog received regular physiotherapy for 1 year. The referring veterinarian performed multiple controls. There was no evidence of lameness at 6 months after the operation, and this remained so until 3 years after surgery when this paper was written.

Discussion

Chronic ATR is a common orthopaedic pathology in both veterinary and human medicine. In human medicine, tendon transposition is often used to repair ATR. The human guidelines for chronic ATR recommend the use of a tendon transposition if an end-to-end repair is not possible (Maffulli and Ajis, 2008). In the case of a small defect, a V-Y lengthening with or without a tendon transfer can be performed (Maffulli and Ajis, 2008). Several techniques exist for tendon transposition in human medicine; for example, transposition of the FBM, M. hallucis longus, or M. flexor digitorum longus have all been performed (Maffulli and Ajis, 2008; Mahajan and Dalal, 2009; Wegrzyn et al., 2010). The literature suggests that, at least for human medicine, none of these methods is better than any another. The veterinary literature describes a technique that involves detaching the FB tendon from its insertion, passing it through a hole drilled in the calcaneus and then suturing it to the proximal tendon end of the AT (Aron, 1990). Sivacolundhu (2001) describes the same method, but this time passing the FBM and FLM through two separate bone tunnels in the calcaneus and finishing with an FLG. Here, we describe a new technique for mechanically reconstructing a chronic ATR with a 2 cm defect. The technique was based on transposition and tenodesis of the FB and FL muscles. The ATR was sutured using a 3LP leaving a 2 cm defect, which was then augmented by an FLG. A tenodesis at the calcaneus was performed with the FB and FL tendons. The concept underlying this muscle transposition is the transfer of part of the force load from the AT suture to the FB and FL muscles, thereby supporting the 3LP suture and the FLG. The tendon transposition should provide immediate and life-long stability to the AT. A 2 cm gap has a poor chance of healing to generate strong tendon tissue (Maffulli and Ajis, 2008). The advantage of this technique over that described by Sivacolundhu (2001) is that the forces are distributed over three structures (the FB, FL and AT). In some cases, the FB and FL tendons are too short to be sutured to the gastrocnemius. However, the technique described herein means that the short tendons of the FB and FL are sufficient for successful tenodesis to the calcaneus.

Figure 4: Post-operative radiographs (A, medio-lateral; B, cranio-caudal) of the tarsal joint showing the modified type II transarticular external fixator (IMEX®).

Hahn et al. (2008) used post-operative magnetic resonance imaging to show flexor hallucis longus hypertrophy after transposition, suggesting functional incorporation into tarsal flexion. Transposition of the FBM in human cases could theoretically induce instability of the tarsal joint (Maffulli and Ajis, 2008); however, no relevant clinical instability has been reported (White and Kraynick, 1959; Maffulli and Ajis, 2008). Here, we observed no tarsal instability during surgery and in later tests. We used the FL and FB muscles because they are easy to isolate and the tendons are long enough to pass through a calcaneus tunnel. According to the literature (Evans, 1993), the FL and FB muscles induce normal flexion of the tarsal joint. The tibialis cranialis and the digitalis extensor longus muscles perform the same function. Thus, normal gait is not impeded by loss of the flexor function of the FLM and FBM.

Augmenting the ATR suture may not be required in dogs (King and Jerram, 2003) with acute tendon laceration because evidence from human medicine suggests that primary repair alone has an excellent prognosis (Lee, 2007; Pajala et al., 2009). However, augmenting the primary repair has been suggested for both humans and animals to improve the immediate strength of the repair and to induce neovascularization of the tendon (King and Jerram, 2003; Gilbert et al., 2007). Baltzer et al. (2009) described a technique for repairing an ATR using a semitendinosus muscle flap. Their concept was to improve the blood supply to the repaired tendon by using a highly vascularised muscle. They performed an end-to-end repair of the AT in all cases. It is unclear whether this method is also suitable for an ATR with a defect. In our case, we decided to use an FLG to facilitate better vascularisation and increased mechanical support of the AT because this is a well-documented method (Demirkan et al., 2004; Maffulli and Ajis, 2008) and using an autograft means that the surgery is relatively simple. The use of a synthetic graft is also described in the literature (Maffulli and Ajis, 2008; Gall et al., 2009; Spinella et al., 2010). The advantage of synthetic grafts is the absence of a donor site. However, such grafts have a higher risk of infection due to the foreign material involved (Maffulli and Ajis, 2008) and are also more expensive.

Because of the weight of the dog the remaining defect between both tendon ends, and the chronicity of the rupture, we decided to use a TEF for 4 weeks. The idea was to first put as little force as possible on the repaired AT. However, because the TEF broke after 3.5 weeks we decided to apply a splint bandage to allow some movement because at 3.5 weeks post-surgery the proliferation phase of the tendon healing process is less important than the remodelling phase (Lister et al., 2009). During the remodelling phase, the application of low levels of tensile force encourages new collagen fibrils to align in the direction of the applied force (Curwin, 2005). Lister et al. (2009) showed that immobilisation with a TEF had no effect on maximum strain in a weight bearing situation. However, they did not show any correlation between the strain within a tendon and the applied force. They hypothesised that the clinical benefits of immobilisation may result from decreased weight bearing, which is attributable to the method of immobilisation. Neither did they compare a TEF with splint immobilisation; therefore, the real impact on tendon healing is unclear.

Niels and Pluhar (2006) examined several immobilisation techniques (TEF, splint, or cast) and found no difference in outcome or complication rate. In the present case, the two distal metatarsal half pins broke, probably due to excessive stress. The placement of larger pins and/or an increased number of pins in the metatarsal bones may have prevented this. A calcaneal pin would also increase the stiffness of the frame and take strain off the metatarsal pins. However, because the two bone tunnels in the calcaneus were already drilled, the use of a calcaneal pin was unsafe. This technique was successful for this 48 kg dog with a chronic ATR; however, it would be interesting to apply this technique to a larger number of dogs to confirm the advantages and to compare the results with those of other methods.

Conclusion

The use of an FLG coupled with transposition and tenodesis of the FB and the FL muscles for the mechanical reconstruction of the ATR should be considered for cases involving chronic ATR with a defect to increase the stability of the AT suture and to stimulate tendon healing.

Acknowledgement

The authors thanks Dr. med. Vanessa Kraege for support and translation.

References

Aron D. N., Tendons. In: Current techniques in small animal surgery. Ed. M. J. Bojrab, Lippincott Williams & Wilkins. 1990, 556–561.

Badylak S. F., Tullius R., Kokini K. et al.: The use of xenogeneic small intestinal submucosa as a biomaterial for Achilles tendon repair in a dog model. J. Biomed. Mater. Res. 1995, 29: 977–85.

Baltzer W. I., Rist P.: Achilles tendon repair in dogs using the semitendinous muscle: surgical technique and short-term outcome in five dogs. Vet. Surg. 2009, 38: 770–779.

Curwin S. L.: Rehabilitation after tendon injuries. In: Textbook of Tendon injuries. Eds. N. Maffulli, P. Renstrom and W. B. Wayne Springer 2005, 242–266.

Demirkan I., Atalan G., Cihan M., et al.: Replacement of ruptured Achilles tendon by fascia lata grafting. Veteriner Cerrahi Dergisi 2004, 10: 21–26.

Evans H. E.: The muscular system. In: Miller's anatomy of the Dog. Ed. H.E. Evans, Elsevier 1993, 258–384.

Fahie M. A.: Healing, diagnosis, repair, and rehabilitation of tendon conditions. Vet. Clin. North. Am. Small Anim. Pract. 2005, 35: 1195–211.

Gall T. T., Santoni B. G., Egger E. L. et al.: In vitro biomechanical comparison of polypropylene mesh, modified three-loop pulley suture pattern, and a combination for repair of distal canine Achilles' tendon injuries. Vet. Surg. 2009, 38: 845–851.

Gelberman R. H., Boyer M. I., Brodt M. D., et al.: The effect of gap formation at the repair site on the strength and excursion of intrasynovial flexor tendons. An experimental study on the early stages of tendon-healing in dog. J. Bone Joint Surg. Am. 1999, 81: 975–982.

Gilbert T. W, Stewart-Akers A. M., Simmons-Byrd A. et al.: Degradation and remodeling of small intestinal submucosa in canine Achilles tendon repair. J. Bone Joint Surg. Am. 2007, 89: 621–630.

Hahn F., Meyer P., Maiwald C. et al.: Treatment of chronic Achilles tendinopathy and ruptures with flexor hallucis tendon transfer: clinical outcome and MRI findings. Foot Ankle int. 2008, 29: 794–802.

King M., Jerram R.: Achilles tendon rupture in dogs. Compendium on continuing education for the practicing veterinarian 2003, 25: 613–620.

Lee D. K.: Achilles tendon repair with acellular tissue graft augmentation in neglected ruptures. J. Foot Ankle Surg. 2007, 46: 451–455.

Lister S. A., Renberg W. C., Roush J. K.: Efficacy of immobilization of the tarsal joint to alleviate strain on the common calcaneal tendon in dogs. Am. J. Ve.t Res. 2009, 70: 134–140.

Maffulli N., Ajis A.: Management of chronic ruptures of the Achilles tendon. J. Bone Joint Surg. Am. 2008, 90: 1348–1360.

Mahajan R. H., Dalal R. B.: Flexor hallucis longus tendon transfer for reconstruction of chronically ruptured Achilles tendons. J. Orthop. Surg. (Hong Kong) 2009, 7: 194–198.

Moores A. P., Owen M. R., Tarlton J. F.: The three loop pulley suture versus two locking loop sutures for the repair of canine Achilles tendons. Vet. Surg. 2004, 33: 131–137.

Moores A. P., Comerford E. J., Tarlton J. F.: Biomechanical and clinical evaluation of a modified 3-loop pulley suture pattern for reattachment of canine tendons to bone. Vet. Surg. 2004, 33: 391–397.

Nielsen C., Pluhar G. E.: Outcome following surgical repair of Achilles tendon rupture and comparison between postoperative immobilization methods in dogs. Vet. Comp. Orthop. Traumatol. 2006, 19: 246–249.

Pajala A., Kangas J., Sirra P. et al.: Augmented compared with Nonaugmented surgical repair of a fresh total Achilles tendon rupture. A prospective randomized study. J. Bone Joint Surg. Am. 2009, 91: 1092–1100.

Sivacolundhu R. K., Marchevsky A. M., Read R. A. et al.: Achilles mechanism reconstruction in four dogs. Vet. Comp. Orthop. Traumatol. 2001, 14: 25–31.

Spinella G., Tamburro R., Loprete G. et al.: Surgical repair of Achilles tendon rupture in dogs : a reveiew of the literature, a case report and new perspectives, Vet. Med. (Praha) 2010, 55: 303–310.

Wegrzyn J., Luciani J. F., Philippot R. et al.: Chronic Achilles tendon ruptures reconstruction using a modified flexor hallucis longus transfer. Int. Orthop. 2010, 34: 1187–1192.

White R. K., Kraynick B. M.: Surgical uses of the peroneus brevis tendon. Surg. Gynecol. Obstet. 1959, 108: 117–121.

Corresponding author

Dr. med. vet. Kevin Diserens
Cabinet vétérinaire Dr. Gmür
Ch. du beau-rivage 6
1006 Lausanne
Tél: 021 616 76 16
Mobile: 079 342 77 65
Fax: 021 616 76 68
E-Mail: kdiserens@veterinaire-lausanne.ch