Superficial digital flexor tenotomy immediately relieves pain associated with paw pad keratomas in three dogs: a case report

Nicola Martinez*, Beth McDonald
University Veterinary Teaching Hospital

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Abstract: This case report of three cases describes a simple surgical treatment for the relief of pain associated with paw pad keratomas (or corns) in dogs. A paw pad keratoma is a mass formed by a localized hyperkeratosis of the stratum corneum on the paw pads, which can be painful, causing lameness. The surgical technique involves a tenotomy of the superficial (and deep in case one) digital flexor tendon of the affected digit which alters the weight bearing position of the toe, thus reducing pressure on the painful pad. All the dogs in this report had an immediate reduction in lameness and rapid post-operative recovery. To date, lameness has not recurred in any of the cases described in this report.

Key words: dog, keratoma, tenotomy

Introduction

Paw pad keratomas are circumscribed areas of hyperkeratosis that occur on the centre of the footpads of dogs and they can cause considerable pain and lameness. They occur almost exclusively in Greyhounds or similar breeds (Whippets, Lurchers) and in these breeds a pathogenesis for the lesions has not been demonstrated. It has been reported that keratomas affect around 6% of retired racing Greyhounds, and approximately 90% of keratomas occur in digits three and four, with 90% found in digits of the thoracic limb. Various theories have been proposed for the pathogenesis of paw pad keratomas, including the presence of small foreign bodies in the subcutis of the pad, viral papillomatosis, or as the result of mechanical abnormalities associated with chronic low-grade pressure. A study of the clinical and histological features of wart-like lesions in 24 dogs, found that none of the Greyhound specimens were associated with papillomavirus.

*Correspondence to: Nicola Martinez, (University Veterinary Teaching Hospital), 65 Parramatta Road, Camperdown, NSW 2050, Australia
E-mail: Nicola.martinez@sydney.edu.au
Treatments have centred on removal of the corn by surgical excision\textsuperscript{7}, or topical treatments such as salicylic acid, urea or imiquimod, aimed at altering the rate of keratinocyte cell turn-over\textsuperscript{1, 4}. These treatments may achieve a reduction in hyperkeratotic tissue, but in many cases the lesions will recur and continue to cause pain. A recurrence rate of 50\% after surgical removal was reported by Guilliard, Segboer and Shearer\textsuperscript{3}. Repeated treatments are often required which may not be favourable to the patient or client. Alternative techniques have been explored such as the insertion of silicone gel under the epidermis of the footpad but results from preliminary clinical studies were disappointing\textsuperscript{7}.

This report describes a novel surgical treatment that was first described by Dr. Michael Guilliard of the Greyhound Health Initiative\textsuperscript{7}, which can provide rapid relief from the lameness associated with paw pad keratomas. A tenotomy of the superficial (and in some cases also the deep) digital flexor tendon of the affected toe alters the weight bearing position of the toe, thus taking pressure off the keratoma. Also, it has been reported that the keratomas will then grow out once the abnormal stress has been removed or corrected\textsuperscript{3, 7}. This technique has been described by Dr. Guilliard on his web site\textsuperscript{7}, but this is the first case report, to the best of the authors’ knowledge, to describe the surgical treatment with tenotomy of the superficial digital flexor tendon of the affected digit for cure of the lameness associated with paw pad keratomas in dogs.

\textbf{Case Report}

Case one: A six-year old male neutered ex-racing Greyhound was presented to the veterinary hospital in July 2019 for investigation of a two-year intermittent lameness affecting the right forelimb and both hindlimbs. The owners had been applying a softening balm (unknown medication and frequency of application) to the paw pads for presumed keratomas. The dog was presented to the referring veterinary surgeon two months prior to referral and mild resentment was elicited on extension of the shoulders. Radiographs were performed which revealed mild mineralisation of the supraspinatus tendon of both forelimbs. Treatment was initiated with oral Meloxicam (0.1 mg kg\textsuperscript{-1} Metacam; Boehringer Ingelheim Animal Health Australia Pty Ltd, North Ryde, NSW, Australia) for two weeks, which only provided mild improvement. The dog was referred for an orthopaedic evaluation. A full orthopaedic examination revealed pain on digital palpation of the pad of digit four (DIV) on the right forelimb (RF), digit three (DIII) on the left forelimb (LF) and left hindlimb (LH), and digit two (DII) on right hindlimb (RH). On all affected digits there was hyperkeratosis in the centre of the pads which could appreciated visually and by palpation. No pain was elicited on manipulation of the hips, stifles, shoulders, neck or back but there was reduced mobility in the carpi joints. The pain elicited on palpation of the digits, and lack of painful response on shoulder extension, led to the assumption that the lameness was likely to have been related to the paw pad lesions and the mineralisation of the supraspinous tendons as seen on radiography, was an incidental finding.

Case two: A nine-year old male neutered Whippet was presented for investigation of intermittent right forelimb lameness in June 2018. This had been occurring for approximately three years and was reported to be more noticeable when the dog was exercised on hard surfaces. On clinical examination, there was mild discolouration of the pads of DIII of the RF and DIV of the LF, and there were central, circular areas of hyperkeratosis (Fig. 1.), and pain on palpation of the pads. The dog was only mildly reactive on palpation of the pad of DIV of the LF, so surgery was only recommended for the lesion on DIII of the RF. A keratoma was diagnosed based on the clinical appearance of a hard, central, circular area of hyperkeratosis with digital pressure eliciting a pain reaction. Pre-anaesthetic blood work including biochemistry, PCV and total protein was performed with no abnormalities detected. The keratoma on the pad of DIII of the RF was surgically removed using sharp dissection under general anaesthesia, but the keratoma recurred five months later. A second surgical procedure was performed, this time as well as removing the keratoma by sharp dissection, a neurotomy of the proper palmar digital nerves on either side of phalanx one of DIII was performed. Recovery and resolution of lameness was good until the keratoma reformed five months later. In April 2019, treatment was initiated with topical imiquimod cream (5\% Aldara; iNova Pharmaceuticals Pty Ltd, Chatswood, NSW, Australia) applied to the corn three times weekly for 16 weeks. The lesion resolved and the dog was pain free for eight months. However, a subsequent 16-week course of three times weekly application of imiquimod initiated when the keratoma recurred in January 2020, failed to resolve...
Case three: A four-year old male neutered ex-racing Greyhound was presented for investigation of a two-year duration of intermittent left forelimb lameness in July 2017. There was severe pain on palpation of the pads of DIII of the LF and LH and central circular areas of hyperkeratosis were identified on the pads. No abnormalities were found on pre-anaesthetic blood work including biochemistry, PCV and total protein. Surgery was performed to remove the hyperkeratotic tissue of the DIII lesion on the LF and a digital neurectomy was also performed. There were post-operative complications including inflammation of the keratectomy site as well as ulcerative lesions developing on the limb from repeated dressings. These complications took over 12 weeks to resolve and the dog was still mildly lame. The dog returned to the clinic 21 months later (September 2020) for lameness on the LF and on examination, areas of hyperkeratosis were identified on the pads of DV on the LF, DII of the LH and DIII of the RH, that were painful on digital palpation.

Other causes of lameness were considered including orthopaedic, neuropathic, and soft tissue injuries. The clinical appearance of a hard, circular area of hyperkeratosis on the pad with a positive pain response on palpation of the lesion, as well as the breeds of dogs affected, was deemed diagnostic for a paw pad keratoma. Further investigation or histopathology was not performed in any of the cases, but other differentials for similar appearing paw pad lesions would include a foreign body, papillomavirus, cutaneous horn, and vasculopathy. The underlying causes for the lesions in these cases was unknown, but cases one and three were both ex-racing Greyhounds which may have been a factor in the underlying etiology.

**Treatment**

Case one: In October 2019 a novel surgical approach was performed to dissect both the superficial and deep digital flexor tendons of the digits associated with the paw pad keratomas. The dog was anaesthetised (medetomidine [10 μg kg⁻¹ Medetomidine injection; Ilium, Troy Laboratories Australia Pty, Glendenning, NSW, Australia] and methadone [0.3 mg kg⁻¹ Methadone injection; Ilium, Troy Laboratories Australia Pty, Glendenning, NSW, Australia] premedication, induction with alfaxalone [1 mg kg⁻¹ Alfaxan; Jurox Animal Health, Rutherford, NSW, Australia] and isoflurane [VCA ISO Inhalation Anaesthetic; Veterinary Companies of Australia Pty Ltd, Kings Park, NSW, Australia] in oxygen for maintenance) and digital nerve blocks were performed by injecting bupivacaine (5 mg 0.5% Bupivacaine injection; Pfizer Pty Ltd, West Ryde, NSW, Australia) on the medial and lateral side of each affected digit. The tendon supplying the digit affected by the pad keratoma was identified by palpation and visualisation through the skin when the digit was placed in extension. A 2 cm linear incision running proximal to distal was made on the palmar/plantar surface running 1 cm distal of the metacarpal/metatarsal pad to the first phalanx, over the flexor tendon of the affected digit. Blunt dissection was used to expose the digital flexor tendon sheath and the sheath was incised to expose the superficial flexor tendon. Further blunt dissection was performed to expose the deep digital flexor tendon and fine curved artery forceps were passed under the tendons. Both tendons (superficial and deep) were incised using sharp dissection with a no.11 scalpel (Swann-Morton, Sheffield, England). The procedure was performed for all the digits affected with pad keratomas (DIV RF, DIII LF, DII RH, DIII LH). The skin was closed with 4-0 poliglecaprone 25 (Monocryl; Ethicon, Chihuahua, Mexico) in a cruciate pattern. Light dressings were applied to all four feet and removed 24
hours post-surgery. The dog was discharged 24 hours post-surgery with a five-day course of oral meloxicam (0.1 mg kg\(^{-1}\) Metacam; Boehringer Ingelheim Animal Health Australia Pty Ltd, North Ryde, NSW, Australia).

Cases two and three: The same surgical procedure was performed as described for case one for the affected digits (DIII RF for case two (Fig. 2.), DV LF for case three), but only the superficial digital flexor tendons were incised. Both dogs were discharged 24 hours post-surgery, and neither dog was sent home with any further medications.

In all cases visible alteration to the position of the digits was evident immediately post-surgery (Fig. 3.). At the 10-day post-operative check-up all dogs were free of lameness, and to date, lameness associated to the pad keratomas has not recurred in any of the dogs. Follow ups with cases one and two (eight and five months post procedures respectively), revealed that the dogs showed no recurrence of lameness and the corns appeared to have grown out (Fig. 4 of case 2). The owners of all three cases indicated satisfaction with the results of the procedure.

**Discussion**

This case report describes a treatment technique that relies on altering the digit position and therefore weight bearing surface of the paw pad, by surgically

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**Fig. 2.** A photo showing the incised superficial flexor tendon.

**Fig. 3.** A photo showing the altered position of the toe 24 hours post surgery of the dog in case two. Note that the dog is fully weight bearing on the foot at rest whilst prior to surgery he would hold the limb up.

**Fig. 4.** A photo of the affected foot of case two taken five months post surgery. The arrow points to the area of the previous keratoma lesion on the pad of digit three, which has since grown out.
incising either the superficial flexor tendon alone or in combination with the deep digital flexor tendon. This has the effect of allowing the dog to avoid applying pressure to the painful area of pad (site of keratoma), thereby relieving the lameness associated with the keratoma. As was evidenced in these three cases, a reduction in lameness can be seen immediately post-surgical recovery, and in all these cases lameness had not recurred by the time of writing this report.

Although the results have not yet been published, preliminary data from a large study by Guilliard are available on the Greyhound Health Initiative website. The results indicate a positive post-operative reduction in lameness at eight weeks with over 80% of 91 dogs having no lameness. A follow up 12 months later on 30 dogs, revealed that 23 dogs had no lameness, six dogs had slight lameness, and one dog had moderate lameness. All of the owners were very satisfied with the outcome reporting that the dogs were much happier and willing to exercise. Racing dogs had returned to racing and all of the corns had grown out\(^{3}\). In the three cases described in this report, none have had recurrence of lameness associated with the paw pad keratomas at the time of writing this report (five-twelve months post-surgery). Owner satisfaction has also been excellent in all three cases.

Previously reported techniques such as surgical excision of corns often provide unsatisfactory outcomes according to the owners (approximately 60% of owners reported the results to be unsatisfactory in one report)\(^{32}\), and recurrence rates can be high (in one study, 52% of keratoma cases treated by surgical removal had recurrence of the keratoma and associated lameness within five years)\(^{33}\). Surgical techniques that remove the lesioned tissue can also result in prolonged recovery as the dog often requires repeated dressings until the pad has healed, and as the dog is still weight bearing on the affected area there will be post-operative pain and inflammation. This can be appreciated in case three where the initial surgical resection resulted in post-operative complications that took over 12 weeks to resolve. The flexor tenotomy technique involves a small 2 cm skin incision that is away from the weight bearing pad so post-operative pain should be minimal and healing rapid. In all three cases reported here, the surgical site from the flexor tenotomy had healed by 14 days post-surgery and all the dogs had full resolution of their lameness.

Surgery for case one involved tenotomy of both the superficial and deep digital flexor tendons whilst the other two cases only had the superficial digital flexor tendon incised. When the technique was first described by Dr Michael Guilliard it was recommended to incise both tendons, but an update on the Greyhound Health Initiative in March 2020 advised that the results are comparable if only the superficial flexor tendon is incised, and the position of the toe is affected less\(^{34}\). In the cases described in this report we also found the results to be comparable when only the superficial flexor tendon was excised in cases two and three, than when both the superficial and deep digital flexor tendons were incised (case one). Although the cosmetic appearance in case one of the dropped toes is more striking as the deep digital flexor tendons were also excised, there have been no other complications associated with these dropped toes in the 12 months post-surgery.

There are some potential post-operative complications that should be discussed. One potential complication is the possibility of keratomas forming on other digits. This is a plausible concern and as the cases described in this report do not have follow up data available beyond 12 months, the potential for recurrence of lameness due to new keratomas affecting other digits is unknown. Other concerns would be whether the altered position of the toe can lead to increased nail growth or problems with the altered weight bearing such as skin lesions on the new weight bearing area of the toe. In the cases described here, there have been no reported complications, and increases to the length of the nails have been easily managed with regular trimming.

As the flexor tenotomy technique does not remove the hyperkeratotic tissue, histopathology was not performed in these cases, so a histopathological diagnosis of a keratoma cannot be made. There is a possibility that the lesions may have been due to other causes (such as neoplasia or a foreign body) so resolution of the disease process in these cases cannot be guaranteed. A fine needle aspirate of the hyperkeratotic lesion for cytology or a punch biopsy for histopathology, may have been beneficial to rule out the other differentials.

In summary, tenotomy of the superficial flexor tendon of the digit affected by a paw pad keratoma can provide an alternative treatment to reduce the lameness associated with paw pad keratomas. It is a relatively quick and straightforward surgical technique, and post-operative recovery and resolution of lameness
associated with the keratoma can be rapid. Diagnosis of keratomas is often made by visual appearance of a circular area of hyperkeratosis of the pad and pain on palpation of the lesion. Adequate investigation of potential underlying causes of the lesion should also be addressed to try and avoid recurrence on other digits, and further investigation such as histopathology should also be considered to confirm a diagnosis.

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