Surgical treatment of simple syndactylism with secondary deep digital flexor tendon contracture in a Basset Hound

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Summary
A five-month-old, female Basset Hound was presented for lameness associated with a fused 3rd and 4th digital pad on the left hind limb (simple incomplete syndactyly), and secondary contracture of the deep digital flexor tendon of the 3rd and 4th digit. An amputation of the third phalanx of the third and fourth digits was performed. Following the operation, the dog gained good use of the affected limb for one month until intermittent non-weight bearing lameness developed. A second surgery was performed six months later, partially removing the second phalanx of digits three and four. Follow-up reports indicate that the dog is doing well and is without lameness. This is the first report of deep digital flexor tendon contracture and surgical treatment of this complication in canine simple syndactyly.

Keywords
Syndactyly, dog, deep digital flexor tendon, contracture

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Introduction
Syndactyly is a dysostosis caused by a congenital differentiation defect between two or more digits, which results in abnormal soft tissue or osseous separation between digits (1–5). It may be classified as ‘simple’ if the connection between adjacent digits consists only of skin and fibrous tissue, and as ‘complex’ if the condition also includes a lack of separation of bones. Syndactyly is called ‘complete’ when adjacent digits (phalanges 1 through 3) are connected throughout their entire length with soft tissue and/or osseous malformation, and ‘incomplete’ when they are only partially connected (6, 7). Complex syndactyly is further classified as complicated or uncomplicated. Complicated complex syndactyly is associated with other anomalies while uncomplicated complex syndactyly is not (6, 7). With the exception of one family of Australian Shepherd Dogs, a genetic aetiology for canine syndactylyism has not been demonstrated.

Methods and results
A five-month-old, female Basset Hound was referred for left hind limb lameness. The dog had been purchased from a pet store six weeks prior to presentation, and the lameness was first noted the second day after adoption. Initially, it was intermittently painful and non-weight bearing, but over time, the clinical signs became more continuous, and dog appeared to warm out of the lameness in the morning, but by the evening it was reluctant to use the limb. Prior to presentation, the patient’s activity had been restricted, but this had not resulted in improvements of her lameness.

On examination the dog exhibited left hind limb lameness. The third and fourth toe of the left hind limb were normal dorsally, however, the digital pads of the third and fourth toe were fused (Fig. 1A-D). There was moist dermatitis around the fused digital pad. Further inspection demonstrated hyperflexion of the toes of the third and fourth digit and plantar deviation of the nails of the third and fourth digit (pointing towards the ground rather than forwards) that could not be manually corrected (Fig. 1A-D). The physical examination was otherwise within normal limits; there was not any evidence of other congenital abnormalities.

Radiographs with the affected foot in a weight-bearing position demonstrated hyperextension of all metatarsal-phalangeal joints. In addition, there was hyperflexion of the proximal and distal interphalangeal joints of the third and fourth digit. There was also an increased opacity and thickened cortices of the second phalanx of the third and fourth digit, and abnormal shape and direction of the third phalanx of the third and fourth digit. The third phalanx of the second, third and fourth digit was deviated in plantar direction (Fig. 2A-C). There was not any evidence of complex synostosis. The fifth digit appeared normal and unremarkable.

Because conservative management had been unsuccessful, in order to alleviate the lameness, surgery of the third and fourth digit was performed. The patient was premedicated with acepromazine (0.01 mg/kg IM) and hydromorphone (0.1 mg/kg IM).

a Acepromazine, Phoenix Laboratories, St. Joseph, MO, USA.

b Hydromorphone HCl, Baxter Healthcare Corp., Deerfield, IL, USA.
Following induction with propofol (6 mg/kg IV), the patient was intubated and maintained on isoflurane and oxygen. Cefazolin (22 mg/kg IV) was administered after induction and two hours after the beginning of surgery. A bupivacaine tarsal block (1.0 mg/kg SQ) was administered prior to preparation of the left hind limb. A plantar approach was made to the phalanges. The fourth digit was isolated and incised at the junction of the digital pad and skin. The deep digital flexor tendon of the third and fourth digit was identified and transected (11). Because of periarticular fibrosis, the tenotomy of the deep digital flexor tendon did not result in a significant resolution of the deviation of the third phalanx of the third and fourth digit, and the distal phalangeal joint could only be partially extended manually. Consequently, a tenectomy and onychectomy of the third phalanx of digit three and four were performed (12). The defect was closed with a simple interrupted suture pattern using 4–0 PDS. The skin was apposed with simple interrupted cruciate sutures using 3–0 nylon.

The recovery from anaesthesia was uneventful. Buprenorphine (0.005 mg/kg SQ) was administered for post-operative pain management and a modified Robert-Jones bandage was placed to prevent post-operative swelling. Meloxicam (0.1 mg/kg PO q24h) was started the morning following surgery and continued for five days. The morning following surgery, the dog was weight bearing and showed signs of improvement. The patient was sent home the day following surgery with instructions for strict cage confinement with short leash walks outside for elimination purposes. The owners were given instructions to return in four to six months (end of the growth period) for re-evaluation of limb function, or sooner should the lameness fail to resolve. The bandage and sutures were removed after seven days, and the incision healed without any complications.

Five months following initial presentation and surgery, the patient returned for re-evaluation. The lameness had improved significantly during the first month post-operatively, but thereafter the lameness had become more severe with increased frequency. Physical examination revealed mild lameness with corn-like growths in the area of the previous surgery on digits three and four. Manipulation of the phalanges of the third and fourth digit demonstrated hyperflexion of the proximal interphalangeal joints of digits three and four with mild discomfort on palpation on the digital pads. Radiographs demonstrated irregular margins on the distal portion of the second phalanx of the third and fourth digits (Fig. 2D). A second surgery was recommended to remove the growths and to restore extensor function to the proximal interphalangeal joints and thus full use of the hind paw.

The dog was pre-medicated, induced, and maintained on general anaesthesia and perioperatively medicated as in the aforementioned protocol. Circumferential incisions were made around the soft tissue growths, and they were removed and sub-

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Fig. 1  A) Mediolateral view of the affected pes at presentation — Hyperflexion of toes. The nail of the second digit is pointing in the normal cranial (forwards) direction whereas the third digit is pointing distally. B) Palmar view of the affected pes at presentation — complete fusion of the third and fourth digital pad. Note the abnormal positioning and wear pattern of the nails of the third and fourth digit. C) Dorsal view of the affected pes at presentation — the toes of the third and fourth digit are invisible. D) Mediolateral view of the normal pes — The nails are off the ground and pointing in cranial (forwards) direction.

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*Propofol,* Baxter Healthcare Corp, Deerfield, IL, USA.

*Isoflurane,* Minrad, Inc., Bethlehem, PA, USA.

*Cefazolin,* Watson Laboratories, Corona, CA, USA.

*Bupivacaine,* Abbott Laboratories, Abbott Park, IL, USA.

*PDS,* Novartis Animal Health US, Inc., Greensboro, NC, USA.

*Ethilon,* Novartis Animal Health US, Inc., Greensboro, NC, USA.

*Buprenex,* Reckitt Benckiser Healthcare, Hull, UK.

*Metacam,* Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO, USA.
mitted for histopathology. The circumferential incisions were extended dorsally, and the underlying soft tissues were elevated off the second phalange of the third and fourth digit. The second phalange of the third and fourth digit were removed with rongeurs until the proximal interphalangeal joint could be extended. Approximately half of each second phalange was removed. Reconstructive procedures were not performed on the digital pad. The subcutaneous tissue was closed using 4–0 PDS in a simple interrupted pattern, and the skin was closed using 4–0 nylon in a simple interrupted pattern. A soft padded bandage was then placed, and recovery was without any complications.

Histopathology reports on the removed growths revealed a thickened stratum corneum and a hyperplastic epidermis with accentuated pegs, acanthosis, hypergranulosis and hyperkeratosis. Histological impression was papillomatous hyperplasia consistent with benign warty papules found in people at distal amputation sites due to chronic, repetitive trauma.

The dog was discharged the day after surgery with instructions for restricted activity and Carprofen\textsuperscript{a} administration (1.3 mg/kg PO BID). At eight months post-operatively it was reported, by the owners, to be using the limb without any lameness or any other complications.

**Discussion**

In this report, the clinical course and successful treatment of lameness caused by simple incomplete syndactylism complicated by secondary contracture of deep digital flexor tendons were described. This is the second reported case of surgical treatment of the problem.

The deep digital flexor muscle of the pelvic limb consists of a lateral head and a medial head that fuse together to form the common deep digital flexor tendon, which branches off to the plantar surface of the base of each third phalange (13). The function of the deep digital flexor muscle of the pelvic limb is to extend the tarsus and to flex

\textsuperscript{a} Rimadyl, Pfizer Animal health, Exton, PA, USA.
the digits (13). Contracture of the deep digital flexor muscle, which results in hyperflexion of the digits, has not previously been described. We were unable to determine the initial cause of the contracture. Since only two toes were affected, the cause of the contracture and the deformity must have been distal to the branching of the common tendon into tendons going to the digits. Therefore, we hypothesized that the simple incomplete syndactyly in this patient caused diminished length growth of the distal portion of the flexor tendons of the third and fourth digit with normal length growth of the metatarsals and the phalanges. Over time, this may have resulted in peri-tendinous and peri-articular fibrosis, and further accentuation of the contracture and deformity.

The initial tenotomy and onychectomy did not result in a complete or permanent resolution of the lameness. We believe that this lameness was due to the continued contracture and malposition of the second phalanx of digits 3 and 4. Due to persistent lameness, we performed amputation through the body of P2, which ultimately resolved the lameness. It was recently reported that lameness may occur with amputation of the digit through bone rather than at the joint (14). Thus, the resolution of the lameness in the present case may suggest that lameness will not necessarily occur following digit amputation through a phalanx. The recurrence of the lameness following the first surgery and the resolution of the lameness following the second surgery suggest that resolution of the contracture deformity should be the goal of a surgical correction. Therefore, if contracture deformity is not resolved with tenotomy or onychectomy intraoperatively, further amputation should be considered until the deformity is resolved.

Syndactylism is an uncommon condition in dogs and there is little known about its presentation, and breed, gender or genetic predispositions. However, a review of 11 reports of canine syndactylism and our case (Table 1) provides some insights (3, 4, 8–10, 15–20). All forms of syndactylism have been diagnosed. Four out of 11 syndactylous cases had additional congenital defects (complicated syndactylism). In only one of the 11 reports of canine syndactylia, a family of Australian Shepherd Dogs (19, 20), was a genetic aetiology demonstrated. Of the reported individual cases, six

Table 1: Canine syndactylia.

<table>
<thead>
<tr>
<th>Classification†</th>
<th>Signalment (breed, sex, age at presentation)</th>
<th>Limbs and areas affected</th>
<th>Other anomalies</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple incomplete</td>
<td>Basset hound, female, 5 months old</td>
<td>LF* (Digit 3 and 4)</td>
<td>None</td>
<td>Present case</td>
</tr>
<tr>
<td>Simple Complete</td>
<td>Golden Retriever, male, 8 months old</td>
<td>LF* (Digit 3 and 4)</td>
<td>None</td>
<td>(4)</td>
</tr>
<tr>
<td>Complex incomplete uncomplicated</td>
<td>Great Dane, male, 9 weeks of age</td>
<td>LF, RF* (Metacarpals and, phalanges*, digit 3 and 4)</td>
<td>None</td>
<td>(8)</td>
</tr>
<tr>
<td>Complex complete uncomplicated</td>
<td>German shepherd dog, male, 16 months old</td>
<td>LR, RR* (Phalanges 1–3, digit 3 and 4 and distal metatarsals of digit 3 and 4)</td>
<td>None</td>
<td>(15)</td>
</tr>
<tr>
<td>Complex complete uncomplicated</td>
<td>Foxhound, female, 12 weeks old</td>
<td>RF (Phalanges 1–3, digit 4 and 5)</td>
<td>None</td>
<td>(10)</td>
</tr>
<tr>
<td>Complex complete uncomplicated</td>
<td>Mixed breed, male, 3 years old</td>
<td>LR, RR (Metatarsal and phalanges 1–3, digit 3 and 4)</td>
<td>None</td>
<td>(3)</td>
</tr>
<tr>
<td>Complex complete uncomplicated</td>
<td>Papillon, female, 1 year old</td>
<td>LF, RF (Phalanges 1–3, digit 3 and 4)</td>
<td>None</td>
<td>(9)</td>
</tr>
<tr>
<td>Complex complete uncomplicated</td>
<td>Papillon, male, 2 years old</td>
<td>LR (Metatarsal and phalax 1, digit 3 and 4 [1 pad for 3rd and 4th digits], incomplete separation, digital pads 1 and 2)</td>
<td>Oligodontia, cheiloschisis</td>
<td>(16)</td>
</tr>
<tr>
<td>Complex incomplete complicated</td>
<td>Mixed breed, female</td>
<td>LF (Metacarpal 1 and 2, metacarpal 4 and 5)</td>
<td>Ectrodactyly</td>
<td>(17)</td>
</tr>
<tr>
<td>Complex complete complicated</td>
<td>Chihuahua, male, 3 months of age</td>
<td>LF (Phalanges 1–3, digit 4 and 5 and distal metatarsal of digit 4 and 5)</td>
<td>Partial terminal transverse hemimelia and an anomalous eighth lumbar vertebra</td>
<td>(18)</td>
</tr>
<tr>
<td>Complex complicated</td>
<td>Family of Australian shepherd†</td>
<td>Palatoschisis, brachygnathia, polydactyly, short tibia-fibula, scoliosis</td>
<td>(19, 20)</td>
<td></td>
</tr>
</tbody>
</table>

† Cases are classified according to the most severe lesion reported; * LF = left pectoral limb, RF = right pectoral limb, LR = left pelvic limb, RR = right pelvic limb; † Not reported in detail; ‡ X-linked lethal or sex-influenced autosomal trait.
were male and four were female. Affected breeds were: Basset Hound (1), Golden Retriever (1), German Shepherd Dog (1), Foxhound (1), Papillon (2), Chihuahua (1), Great Dane (1), Australian Shepherd Dog (1), and mixed breed (2). Other congenital defects that were identified in canine syndactyly without demonstrated genetical aetiology included: oligodontia, cheiloschisis, ectrodactyly, partial terminal transverse hemimelia, and lumbar vertebral anomaly. All syndactyle canine patients presented with lameness were diagnosed with simple syndactyly, whereas all patient diagnosed with complex syndactyly were asymptomatic (3, 4, 8–10).

The case reported herein and this review may provide guidelines for the diagnosis and possible treatment of canine syndactyly. As syndactyly may be a hereditary trait, we recommend that the clinician obtains a detailed history regarding syndactyly in litters, and previous litters (including male-to-female ratio). Information should also be obtained on the first and second trimester of gestation of the bitch to determine possible causative environmental factors (i.e. drug exposure, maternal disease, or radiation). A thorough physical examination should be performed to detect other congenital abnormalities. Even though the radiographic changes associated with complex syndactyly can be very dramatic, this condition does not appear to cause lameness. The two cases affected with ‘simple syndactyly’ were presented for evaluation, and possible treatment, because they were lame. Careful examination of the affected paws is required to determine the cause of lameness. The pathology associated with simple syndactyly may be found on the dorsal (‘webbing’) or plantar (fusion of digital pads) side of the paw. The diagnosis and classification of this condition is based on clinical and radiographic findings. Most syndactyly patients do not require therapeutic intervention with the exception of ‘simple syndactyly’. Dorsal webbing defects may be treated with reconstructive procedures as described by Richardson et al. (4). In addition, palmar or plantar defects resulting in contracture may necessitate digit amputation, as described in this report. Although a hereditary background cannot be demonstrated in most cases of canine syndactyly, the breeding of affected animals should be discouraged. We recommend that affected dogs be sterilised, to ensure that the trait is not propagated.

In this report, we document the clinical course and successful treatment of lameness caused by simple incomplete syndactyly, complicated by secondary contracture of deep digital flexor tendons. We also provide guidelines for the diagnosis and possible treatment of the condition. It is the first report to describe deep digital flexor tendon contracture and surgical correction of this complication of canine simple syndactyly.

References