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A modified technique for treating swimmer puppy syndrome

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ABSTRACT: Swimmer puppy syndrome is an unusual anomaly that affects dogs within the first few days or months of life. This syndrome is characterised by the inability of the animal to maintain a quadrupedal position primarily using the pelvic limbs. In some cases, the condition may also affect the thoracic limbs. Although the exact pathophysiology of this condition remains uncertain, plausible causes include alterations in the neuromuscular synapse, improper myelination or poor development of peripheral motor neurons, delayed muscle development or ventral horn neuropathy. Here, we describe our results using a modified technique for the treatment of swimmer puppy syndrome, based on immobilisation for a period of one to four weeks with the aid of microporous hypoallergenic tapes, plasters and elastic meshes. Our modified method showed clear evidence of improvements.

Keywords: canine; bandage; functional immobilisation; hyperextension; malformation; musculoskeletal disorder; rehabilitation

Swimmer puppy syndrome (SPS), also known as flat puppy or turtle puppy syndrome, is an uncommon anomaly that is characterised by hyperextension of the knee and tarsal joints, along with bilateral hyperextension of the hip joint (Penha et al. 2001). The syndrome affects the motor development of both puppies and kittens due to myofibrillar hypoplasia; it manifests in these animals between the second and third weeks of life, a period during which they more frequently exhibit movement and ambulation without success (Nestle 1968; Nelson and Couto 2015).

SPS is characterised anatomic-functional malformations of the pelvic limbs and, rarely, of the thoracic limbs (Fossum et al. 1989; Hoskins 2001; Yardimci et al. 2009). Nganvongpanit and Yano (2013), in a retrospective study of 2443 cases, reported that 75% of cases involve the pelvic limbs, 15.38% involve all four limbs and 9.62% involve only the thoracic limbs.

The exact mechanisms of SPS are not clearly defined, although several aetiologies and theories have been proposed (Yardimci et al. 2009). Among these, genetic factors associated with alterations in the neuromuscular synapse function, improper myelination or poorly developed peripheral motor neurons, delayed muscle development and ventral horn neuropathy (Lorenz 1977; Fossum 2014) have been highlighted. Environmental factors may also be involved, such as the presence of a smooth floor or excess protein content in the maternal feed during the gestational period (Mello et al. 2008).

Animals with SPS typically present with ventral decubitus exhibiting varying degrees of locomotor difficulty, where the patient performs rowing movements (i.e., similar to the "breast" or "chest" style of swimming) (Hosgood and Hoskins 1998; Verhoeven et al. 2006; Yardimci et al. 2009). Thus, SPS is frequently associated with other diseases, such as pectus excavatum, genu recurvatum, medial

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patellar luxation and heart murmur (Verhoeven et al. 2006; Fossum 2014; Nelson and Couto 2015).

Pectus excavatum is a deformity caused by a shift in the centre of gravity in these animals to the thorax; importantly, the partially formed ribs are unable to maintain their shape. Moreover, the sternum may exhibit abnormal growth of a convex (carinatum) or concave (excavatum) nature, which is frequently observed in cases involving the thoracic limbs, as the animal is positioned in ventral decubitus for a prolonged period (Williams and Crabbe 2003; Verhoeven et al. 2006; Rahal et al. 2008; Nganvongpanit and Yano 2013; Fossum 2014). Dyspnoea, regurgitation, and aspiration pneumonia are observed in severe cases of chest compression, whereas constipation is observed in cases of abdominal and pelvic compressions; in addition, the presence of bedsores and ulcers on the skin is caused by prolonged decubitus (Verhoeven et al. 2006; Fossum 2014).

Because of these congenital changes, genu recurvatum can be observed as a consequence of the contraction of the quadriceps musculature, which results in changes in the knee joint, where the affected limb remains hyperextended along with the tarsus and where the knee may bend caudally. Chronic forms of these changes lead to periarticular and intraarticular degeneration and fibrosis (Montgomery and Fitch 2007).

SPS is found in predisposed chondrodystrophic and small breeds (Dachshund, Yorkshire terrier, Shih Tzu), as well as in dogs that exhibit wide chests and short limbs (Yardimci et al. 2009). Rarely, large dogs can also be affected (Nganvongpanit and Yano 2013), especially those with an accelerated growth pattern, and particularly in litters with few puppies (Verhoeven et al. 2006).

Currently, there is no specific and predefined protocol utilised for the treatment of SPS (Yardimci et al. 2009). To our knowledge, the only available case reports describe treatments based on the realisation of temporary immobilisations, using bandages made of eight-girdle or cuffs and intense physical therapy exercises (Verhoeven et al. 2006; Yardimci et al. 2009).

Verhoeven (2006) has discussed the need for nutritional monitoring with dietary caloric restriction, given the manifestation of SPS in animals that have developed more quickly in the litter. Furthermore, complementary therapy consisting of the administration of selenium and vitamin E has also been used, although this approach is not supported by scientific evidence (Sarmento 2006; McDonald et al. 2011).

The response to, and effectiveness of, treatment are directly related to several factors, including the number of affected limbs, the presence of pectus excavatum or other conditions, the early onset of physical therapy activities and the owner's commitment to following the recommended treatment approach (Hosgood and Hoskins 1998; Verhoeven et al. 2006; Yardimci et al. 2009).

Our hypothesis was that an alternative method of immobilisation, involving an elastic bandage to keep the limbs flexed, could optimise rehabilitation in affected puppies. Here, our objective was to describe this modified technique for the clinical treatment of SPS via temporary external immobilisations.

MATERIAL AND METHODS

The admitted patients with suspected SPS are typically weaned from chondrodystrophic breeds, such as Shih Tzu, Lhasa Apso, Yorkshire, with a history of inability to walk with the pelvic and thoracic limbs or both (this inability is more commonly observed in the pelvic limbs). Moreover, patients include those presenting with bilateral hip flexion; hyperextension of the knee and tarsal joint, which is associated with the presence of genu recurvatum of both knees; and bilateral medial patella dislocation grade III. Depending on the extent of chronic illness, a subset of the patients may exhibit alterations in the sternum, as well as cardiopathies. In general, the condition is observed by the intervening trainer when the patient initiates ambulation attempts. In contrast, neurological and radiographic examinations typically reveal no notable alterations or evidence of bone deformities.

Technical characteristics. The patient should be placed in the quadrupedal position on a flat adherent surface, and should then be stimulated to walk, in order to properly diagnose the anatomical changes (Figure 1A). Continuous and detailed orthopaedic examination should be performed to detect joint changes and angular deviations; in severe cases, radiographic and tomographic images may be required.

To perform the immobilisation technique for SPS correction, several materials are required, includ-

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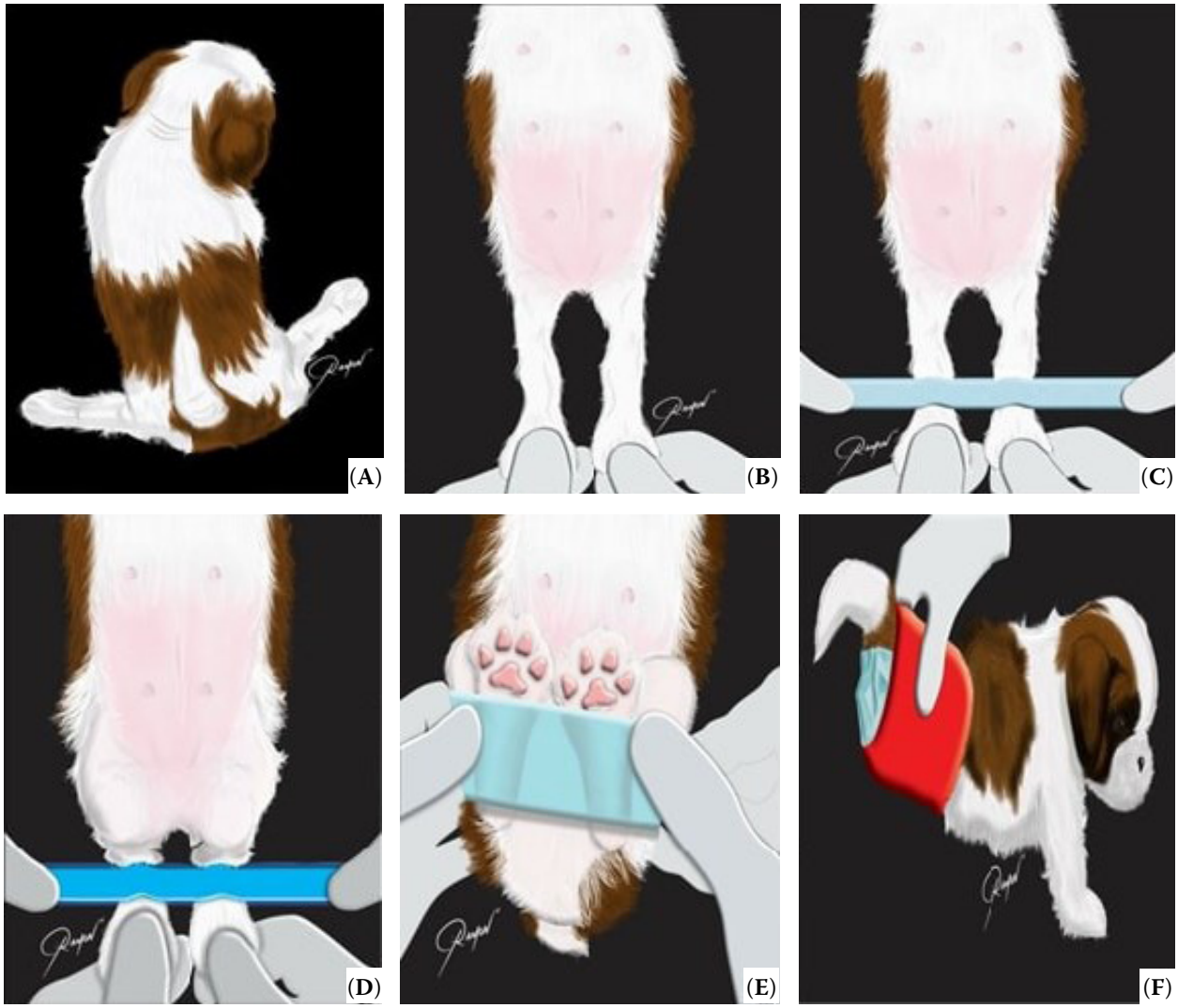

Figure 1. Illustrative images of a canine puppy with swimmer puppy syndrome and step-by-step description of the new technique for the treatment of this condition. (**A**) Dorsal view of a canine puppy exhibiting a typical posture of animals with swimmer puppy syndrome in the pelvic limbs. Note the lateral position of the pelvic limbs, as well as the hyper-extended knees. (**B**) Initial preparation of the bandage for the treatment on canvas; note the placement of the patient in the supine position. (**C**) Use of sections of hypoallergenic tape in the middle portion of the metatarsal diaphysis; one section of tape was placed on the dorsal surface and the other was placed on the plantar surface. (**D**) Note the pelvic limbs arranged parallel to each other, with the knees and tarsus flexed. (**E**) Wider spread of the tape on the pelvic limbs, with the knees and the tarsus fully flexed. The tape was applied until it wrapped around the lumbar region of the animal. (**F**) Final view (lateral position) with the placement of elastic tape (red) on the pelvic limbs, thus providing greater adhesion to the bandage

ing microporous hypoallergenic tape (Micropore®, 3M, Sumare, Sao Paulo, Brazil), waterproof plaster tape (Esparadrapo®, Cremer, Sao Paulo, Brazil), elastic bandage (Coban®, 3M, Sumare, Sao Paulo, Brazil) and Anaseptil Po (Anaseptil®, Farmasa, Sao Paulo, Brazil). It is essential to perform trichotomy of the caudal region of the dorsum, caudal abdomen and pelvic limbs, in an attempt to prevent secondary skin lesions, as well as to facilitate the adhesion of the materials used.

The patient must be restrained manually by an assistant, in order that it remains motionless in the dorsal decubitus position. The pelvic limbs should be free and extended to facilitate their manipulation and the placement of the components of the bandage (Figure 1B).

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Two pieces of microporous hypoallergenic tape, of a length compatible with the size of the patient, should be cut. Subsequently, one piece should be applied to the plantar surface and the other to the dorsal surface of the metatarsals (in the middle diaphyseal region), with the adhesive side facing the limb (Figure 1C). It is important to note that the tape should be placed when the pelvic limbs are fully extended, such that they are parallel to each other and to the spine. Therefore, the assistant should maintain the patient in a motionless state, while the executor applies the tape.

At this stage, Anaseptil Po should be applied to both pelvic limbs and the lumbar region, in order to avoid the formation of cutaneous wounds from secondary bacterial infections associated with immobilisation.

Subsequently, the bandage executor will promote, on several occasions, the simultaneous flexion of the knee and tarsal joints bilaterally, aided by the lateral flaps remaining from the junction of the two tapes (Figure 1D). After certifying that the patient will allow total flexion of the involved joints, the assistant should maintain pressure via the lateral flaps of the pieces of tape, maintaining them in the ventrodorsal direction. Thus, the thighs will remain in contact with the ventral abdomen. Next, the bandage executor will fix the fully flexed pelvic limbs, using waterproof plaster tape that will be applied first to the tape already placed in the metatarsals, and then to the entire lumbar region of the animal (Figure 1E).

To finalise the bandage, an elastic bandage should be applied over the already stabilised pelvic limbs and the patient's dorsal abdominal region, thus increasing the stability of the bandage and preventing the pelvic limbs from escaping fixation (Figure 1F).

The immobilisations should be changed daily, both to perform movements of the involved joints and to observe the ambulatory evolution. After physiotherapy, the patient should remain, for approximately 10 minutes, in a flat and adherent place while being stimulated to ambulate.

The duration of the immobilisation period will vary from one week to one month, depending on the evolution of each case. During this period, the patient should be maintained in confinement, such that the thoracic limbs are not overloaded.

Depending on the progress of the case, the executor may choose to allow the patient periods without the waterproof bandage (1–4 hours daily), but with the first layer of tape (handcuffs) constantly applied (Figure 1C). After this period, the bandage should be applied again. Notably, earlier diagnosis and more rapid treatment will lead to more rapid patient discharge from veterinary care.

Intercurrences of the technique are linked with poor hygiene and basic care, and include uremic and allergic dermatitis. Therefore, the daily exchange of bandages and use of absorbents, particularly in male patients, as well as basic care, should be viewed as essential.

Accompaniment and general care. In general, during the first ten days of wrapping, bandage changes should be performed every 12 hours to enable flexion physiotherapy and controlled extension of the pelvic limb joints. After this first phase, the patients typically exhibit good progress, with a capacity for minimal weight support in the quadrupedal position, as well as reversal of the genu recurvatum. Subsequently, a new 12-hour phase of bandaged immobilisation should be initiated; the remainder of the day should be spent with handcuffs (first stage of bandage, Figure 1C), for seven to ten days. When the patient demonstrates good ambulation, the last phase should be initiated: the handcuff should be maintained for 12 hours (Figure 1C), and immobilisation should not be used for the rest of the day; this should be performed in conjunction with physical therapy exercises overseen by a qualified professional for at least ten days. At the end of the 30-day treatment, patients typically exhibit normal ambulation and an absence or reduction of medial patellar dislocation. Six months of follow-up, with monthly visits to the clinic, should be implemented to verify the stability of the changes.

RESULTS

During the initial period in which this modified technique was used in routine care at the Veterinary Hospital "Governador Laudo Natel," we treated 38 puppies (patients), with ages varying from three to nine weeks. The specific age groups were as follows: five patients (13.1%) at three weeks of age; 12 patients (31.6%) at four weeks of age; six patients (15.8%) at five weeks of age; 10 patients (26.3%) at six weeks of age; three patients (7.9%) at eight weeks of age; and two patients (5.3%) at nine weeks of age. We observed excellent recovery of

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25 patients (65.8%), partial recovery of eight patients (21.0%) and poor recovery of five patients (13.2%). We defined excellent recovery as patients who exhibited the ability to fully walk after rehabilitation, with normal physiological movement of the joints; we defined partial recovery as those patients who were able to walk with some degree of joint instability; and we defined poor recovery as those patients who did not regain the ability to walk or sustain bodyweight. The development of this technique was closely linked to the development of the condition and to concomitant controlled physical exercise. Chronic cases, involving patients who were more than 40 days of age, did not undergo sessions of physiotherapy associated with the technique, as the chances of success and good recovery were minimal.

We observed that, in patients diagnosed at an older age, the therapy was not as effective as it was in younger patients. Notably, cases that showed excellent recovery were primarily diagnosed and began treatment at three to five weeks of age; only two patients who were diagnosed and began treatment at six weeks of age showed excellent recovery at the end of treatment. Patients who exhibited partial recovery began treatment at six weeks of age; patients who exhibited poor recovery began treatment at eight and nine weeks of age.

Only a small number of problems involving urination and defecation, including uremic dermatitis, were observed in treated patients, as the bandage allows maintenance of the penis/vulva and anus outside the immobilisation. We frequently provided bandage changes to the tutors and instructed them to return earlier than expected if these problems arose.

DISCUSSION

Based on previous reports, chondrodystrophic puppies are more predisposed to SPS, especially those of the Shih Tzu breed (Yardimci et al. 2009). Several factors may contribute to the manifestation of SPS to varying degrees, including frequently reported genetic and environmental factors (Lorenz 1977; Verhoeven et al. 2006; Yardimci et al. 2009; Fossum 2014).

The presence of SPS is confirmed when a patient first attempts ambulation, at approximately three weeks of age, and exhibits an inability to maintain the quadrupedal position or support weight in the pelvic limbs. In addition, a patient may demonstrate "paddling" movements with the pelvic limbs during walking (Nestle 1968; Hosgood and Hoskins 1998; Verhoeven et al. 2006; Yardimci et al. 2009; Nelson and Couto 2015). We emphasise the importance of early diagnosis for successful therapy and recommend evaluation of other animals in the litter.

As previously noted, SPS patients exhibit hip flexion, hyperextension of the knee and tarsal joints as well as the presence of genu recurvatum and bilateral patellar medial luxation (Penha et al. 2001; Verhoeven et al. 2006; Fossum 2014; Nelson and Couto 2015) during the initial examination. In addition, these patients do not exhibit haematological or neurological abnormalities (Nestle 1968; Hosgood and Hoskins 1998; Penha et al. 2001; Verhoeven et al. 2006; Montgomery and Fitch 2007; Yardimci et al. 2009; Gonzalez et al. 2012). Other abnormalities, such as pectus excavatum or heart disease, may be observed; however, these abnormalities may arise from a prolonged duration of SPS, as they typically result from deviation of the centre of gravity in these patients due to their musculoskeletal condition. Notably, this demonstrates the importance of trainer awareness in early diagnosis of SPS (Williams and Crabbe 2003; Verhoeven et al. 2006; Rahal et al. 2008; Nganvongpanit and Yano 2013).

This treatment approach is a variation of an existing therapy of immobilisation with bandages and physiotherapeutic exercises (Verhoeven et al. 2006; Yardimci et al. 2009). When applied to the joints involved in hyperflexion, our modified technique ensures greater contact between the joints, allowing anatomical development of bone, tendon and ligament muscle, as governed by Wolff's law (Cordei and Gautier 1999); this preserves the alignment and healthy angulations for the species. The physiotherapy exercises provide a progressive increment of muscle tone, anterior to the correct functional position of the limb, thus conferring additional stability.

It has been noted that appropriate bandage care is essential in this treatment approach, in order to avoid pathologic outcomes, such as oedema and ischaemia (Lorenz 1977). The bandage should be removed consistently, enabling the caretaker to perform controlled physiotherapeutic exercises to guarantee a gain in muscle tone, motor coordination of the limbs and stimulation of tissue irrigation

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(Marsolais et al. 2002; Van Ham 2002). Bandage removal will thus improve the patient's joint and muscular hygiene, as well as enable the assessment of the progress of the case (Verhoeven et al. 2006).

In addition, nutritional monitoring is recommended to ensure a proper diet and regulate the patient's development (Sarmento 2006; Verhoeven et al. 2006; McDonald et al. 2011); this should be performed alongside exercise orientation with a professional physiotherapist (Clark and Mclaughlin 2001; Kathmann et al. 2001; Marsolais et al. 2002; Van Ham 2002; Verhoeven et al. 2006; Yardimci et al. 2009).

When treated early, many patients may recover the ability to walk without pronounced deficits; however, they may retain some sequelae such as medial patellar luxation. This is an acceptable result relative to the severity of the disease at admission, and it is closely related to the timing of the onset of the condition (Hosgood and Hoskins 1998; Verhoeven et al. 2006; Yardimci et al. 2009).

In conclusion, our modified technique has proven to be effective in correcting SPS, especially in cases that involve early diagnosis, adherence of the owner and correct execution of the technique; importantly, our technique enables improved patient recovery.

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