Canine hip denervation: comparison between clinical outcome and gait analysis

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SUMMARY

Generally, hip denervation is presented as an interesting surgical alternative to femoral head and neck osteotomy or total hip replacement to manage hip dysplasia. Nine client-owned dogs, presenting unilateral or bilateral hip dysplasia underwent hip capsule denervation (7 bilateral, 2 unilateral). Prior to surgery and three months after surgery, owners were questioned and the gait of each dog was analysed with a 4.3 meter-long walkway (GAITRite®). Eight out of 9 dogs presented clinical improvement according to owner's opinion and the conclusions of clinical examination. However, gait analysis concluded that only half of the operated dogs seemed to be improved. Given the low cost and few potential complications, hip denervation should be considered to be an interesting procedure for decreasing pain, improving clinical signs, even if it does not modify weight bearing on hind limbs.

Keywords: Hip dysplasia, Dog, Hip denervation, Gait analysis, Clinical improvement.

RÉSUMÉ

Dénervation de la hanche chez le chien : comparaison entre résultats cliniques et analyse de la marche

La dénervation de la hanche représente une alternative intéressante à la résection de la tête et du col fémoral ou à la prothèse totale de hanche dans la gestion de la dysplasie de la hanche. Une dénervation de la capsule articulaire a été réalisée sur 9 chiens présentant une dysplasie unilatérale ou bilatérale (7 bilatérales, 2 unilatérales). En préopératoire et 3 mois après la chirurgie, les clients ont été interrogés et la marche de chaque chien a été analysée à l'aide d'un tapis de marche de 4,3 m de long (GAITRite®), Huit des neuf chiens présentaient une amélioration clinique selon l'avis de propriétaires et l'examen clinique. Cependant, l'analyse de la marche n'a permis de confirmer cette amélioration chez seulement un chien sur deux. Etant donné le faible coût et le peu de complications associées, la dénervation de la hanche peut être considérée comme une chirurgie intéressante dans le but d'obtenir une diminution de la douleur, une amélioration des signes cliniques et ce même si cela n'entraine pas de modification du report de poids sur les membres postérieurs.

Mots clés : Dysplasie de la hanche, Chien, Dénervation de la hanche, Analyse de la marche, Amélioration clinique.

Introduction

Canine hip dysplasia is the main pathology affecting joints in dogs. The associated clinical signs are pain, amyotrophy and lameness. Many procedures have been described to detect hip dysplasia in puppy and to correct it. But many mature dogs are still presenting hip dysplasia and coxofemoral osteoarthritis probably due to a low sensibility of the detecting tests or because owners have declined to check for canine hip dysplasia. In those cases, when medical treatments are ineffective to manage pain, a surgical treatment is necessary. Total hip replacement and femoral head and neck osteotomy are the different procedures that are currently performed to release pain and ambulatory discomfort. However, 10 years ago, a new procedure was published. KINZEL *et al*. [7] presented hip denervation as a successful surgical method for treating dogs suffering from hip joint dysplasia and arthrosis. By destroying the sensory innervation to the craniodorsal aspect of the coxofemoral joint, lameness is improved due to the pain removal.

Objective measurement of improvement remains difficult to evaluate clinically. Many devices have been developed for gait evaluation such as force plate, platform pressure system, treadmill and kinematic devices. The purpose of the present study was to compare clinical improvement observed by owners with clinical examination to objective gait analysis. For that, it was hypothesized that clinical improvement was associated to an increase of weight bearing on hindlimbs during the walk, characterized by an increase of the mean speed and an increase of fore limbs / hind limbs distribution after the surgery.

Materials and Methods

ANIMALS

For this study, we have performed a non-blinded prospective clinical trial. From February 2005 to July 2005, dogs presenting lameness and hip joint dysplasia were included. A thorough clinical examination was performed by a single surgeon to rule out any dog presenting another orthopaedic lesion. During the first consultation, a complete clinical examination was carried out and a first gait analysis was performed. To confirm the diagnostic and to evaluate hip modifications, coxofemoral joints were radiographed in a ventro-dorsal pro-

jection following sedation of the patient with butorphanol (0.3mg/kg intravenously) and medetomidin (2µg/kg intravenously). Osteoarthritis and hip joint sub-luxation were evaluated radiographically and subjectively categorized as "not present" (0), "mild" (1), "moderate" (2) and marked (3).

SURGICAL TREATMENT: HIP DENERVATION

Dogs were firstly sedated with morphine (0.1mg/kg subcutaneously) and acepromazine (0.05mg/kg subcutaneously), then anaesthesia was performed with thiopental (10mg/kg intravenously) and maintained with oxygen and isoflurane delivered via a tracheal tube. An antibioprophylaxy was carried out using cephalexin (30mg/kg intravenously). An anti-inflammatory drug, meloxicam (0.1mg/kg intravenously) was injected preoperatively.

Positioning and surgical approach were performed as described by KINZEL *et al*. [10]. The patient was positioned in lateral recumbency and draped to permit access to the craniodorsal aspect of the hip joint. A lateral approach of the hip joint was carried out. A 5 cm skin incision was made slightly cranial and centred on the greater trochanter. The subcutaneous fat and fascia between tensor *fascia lata* and biceps femoris muscles were incised. After blunt dissection, a Hohmann retractor was placed between the ilium and the gluteal muscles and advanced dorsally until the tip reached the dorsal aspect of the ilium. By using the retractor as a lever, the gluteal muscles were retracted dorsally allowing exposition of the cranial and dorsal aspects of the coxofemoral joint. A strip of periosteum was removed with a sharp curette circularly around the joint capsule from the dorsal aspect to the insertion of the rectus femoris muscle (figure 1). After lavage and suction, the wound was closed routinely. When bilateral procedure was scheduled, the dog was turned on the other side and the second hip was denervated with the same procedure.

Dogs were discharged the same day with meloxicam (0.1mg/kg orally) in order to treat pain if necessary. No instruction of restrictive activity was given to owners.

FIGURE 1 : Per-operative view. A strip of periosteum is removed with a sharp curette (hip join is under the retractor).

FOLLOW-UP

Three months postoperatively, an orthopaedic examination was performed and questions about dog improvement were asked to the owners and dogs walked on the walkway. When dogs walked by their own on the walkway, no speed restriction was applied during the test.

To evaluate improvement, physical examinations before and three months postoperatively were compared. Gait analysis was performed with a modified human gait analysis device (GAITRite® system for a canine application). The GAITRite® system includes a portable walkway of 4.3 meters long with seven sensor pads and a 61 cm x 427 cm active area (Appendix 1). The active area includes 16,128 sensors (7 pads, 2304 cells per pad arranged in 48 x 48) that allow spatio-temporal measurements of different aspects of the gait. Other technical specifications are presented in Appendix 1. Each stance on the walkway induces activation of several 2 inches pressure sensors. The pressure score ranges from 0 to 7 depending on the force applied on the sensor. Data of each paw's stance is collected and recorded at a frequency of 80 Hz by means of specific computer software developed for quadrupeds gait analysis. This device allows the assessment of many parameters; two of them were considered in this study: the maximal pressure and surface of the stance. Surface was defined as the number of sensors activated during the stance, and pressure was defined in N/inch^2 as the maximal pressure applied on the walkway during the stance (maximal value of the sum of the pressures applied on the activated sensors of a paw at a time). Maximal pressure and number of activated sensors were recorded at walk and several trials were performed before surgery and 3 months postoperatively.

Data obtained with the GAITRite® were analysed. Speed (cm/s), maximal pressure (N/inch2) and number of activated captors (half inch square) during the walk. The study was based on comparison between pre-operative and post-operative values and between sound dogs and dysplastic dogs. The ratio fore/hindlimbs was measured and the statistical study was focused on the stance report between hindlimbs and forelimbs for both parameters. This ratio allowed determining and comparing the distribution of the stance before and after the surgery. Results are expressed as a percentage based on the ratio and corresponding to the distribution on the hind limbs for both parameters.

STATISTICAL ANALYSIS

Pre-operative data were compared to post-operative with a non parametric rank sum test (Mann-Witney-Wilcoxon sum test). Pre and post-operative data were also compared with conventional stance report found in sound dog from a previous study using a non parametric sign test. The mean speed was also recorded for each dog to look for a pre and post-operative significant difference with the non parametric rank sum test. The differences were considered as significant when p value was less than 0.05. Results are expressed as mean ± standard deviation.

Results

During this 6-month period, 9 dogs were included in our study and completed the full three month follow-up period. Descriptions of each case are collected in Table I. The mean age of the dogs was 25 ± 19 months, ranged from 7 months to 4.5 years and the mean weight was 26 ± 10 kg (13 to 42 kg). All of them presented hip pain and lameness with hip dysplasia associated with amyotrophy in 5 dogs (56%) and the Ortolani sign was positive in 5 dogs (Table I). Radiographically, the average osteoarthritis score was 1.6 and the average sub-luxation score was 1.5.

Sixteen hip denervations were performed (7 bilateral and 2 unilateral) and the surgery lasted in average 28.5 ± 3.6 minutes. No major complication was encountered and the only minor complication was a seroma on 2 active dogs which was managed by a restricted activity.

Three months after denervation, the owners judged an improvement of the clinical signs on 14 hips (87%) and no real improvement on only 2 treated hips. Seven hips were completely free of lameness. None of the treated dogs displayed any increase of pain after denervation but 2 were lamer due to a cranial cruciate ligament rupture. Eight out of 9 owners were very satisfied with the clinical improvement of their dog and would choose this procedure again. For long-term follow-up, owners were contacted by telephone to evaluate the long-term status of their pets. Two dogs died for reasons unrelated to surgery. One year postoperatively, data were available for five dogs (9 hip denervations). No owner reported an increase of lameness; all of them were still satisfied with the procedure.

Concerning the gait analysis, dogs were tested at walk, with a mean speed of 133.1 ± 34.2 centimetres per second, with a minimum of 81 centimetres per second and a maximum of 220 centimetres per second. Tests with irregular or changing gait were excluded and not analysed. One dog (dog 4) was excluded from the gait analysis because of its inability to cross the walkway at a regular walk. Speed analysis between pre- and postoperative (3 months postoperatively) periods seemed to increase but no significant difference was found: pre-operative mean speed of 126.1 ± 32.6 centimetres per second versus a post-operative mean speed of 139.2 ± 31.2 centimetres per second.

	Dog cases	Clinical examination	Radiological scores		FCI	Surgery	Outcome
			OAS (L/R)	SLS (L/R)	Class. (L/R)	(min)	(3 months follow up)
1	English Setter 9 months 16 kg	Lameness (intermittent) Painful hip mobilisation (slight) Ortolani + Amyotrophy	1/1	2/3	E / E	Bilateral (25 / 27)	No lameness Slight stiffness (hyperextension) Discomfort (circumduction)
2	Labrador retriever 7 months 19.5 kg	Lameness Painful hip mobilisation Ortolani + Amyotrophy (severe)	1/1	2/2	E / E	Bilateral (25 / 25)	No lameness Comfortable during extension Slight discomfort (circumduction)
3	Rottweiler 7 months 37 kg	Lameness Painful hip mobilisation Ortolani +	2/2	2/2	E / E	Bilateral (30 / 35)	No lameness Slight stiffness (hyperextension) Discomfort (circumduction)
4	English Setter 54 months 24 kg	Lameness (intermittent) Painful hip mobilisation (slight) Amyotrophy (slight)	2/2	1/1	C / C	Bilateral (32 / 28)	No lameness Comfortable during extension Discomfort (circumduction)
5	Crossed breed 13 months 29.5 kg	Lameness (left limb) Painful hip mobilisation Amyotrophy (slight)	1/2	1/1	E / C	Bilateral (25 / 25)	No lameness Comfortable during extension Discomfort (circumduction)
6	American Cocker Spaniel 30 months 18 kg	Painful hip mobilisation Ortolani +	2/2	1/1	C / C	Bilateral (28 / 30)	No lameness Slight discomfort (hyperextension and circumduction)
7	Golden retriever 42 months 34 kg	Lameness Painful hip mobilisation (left) Ortolani +	0/2	0/1	C / C	Left (29)	Slight discomfort (hyperextension and circumduction) CCLR (left)
8	Golden retriever 14 months 42 kg	Lameness Painful hip mobilisation Amyotrophy (slight)	2/2	2/1	E / E	Bilateral (35 / 32)	No improvement CCLR (right)
9	Beagle 48 months 13 kg	Lameness (intermittent) Painful hip mobilisation (slight, left) Amyotrophy (slight, leftt)	0/1	0/1	B / A	Left (25)	No lameness Slight discomfort (hyperextension)

OAS: Osteoarthritis score; SLS: sub-luxation score; FCI: Fédération Cynologique Internationale; L/R: Left/Right; A: no sign of hip dysplasia; B: near normal; C: mild hip dysplasia; E: severe hip dysplasia; CCLR: cranial cruciate ligament rupture.

TABLE I: Clinical details of the 9 dysplastic dogs included in the present study.

Inter dogs analysis showed contrasted results. Pre-operative gait analysis presented a stance report between fore and hindlimbs significantly different from sound dogs; stance on hindlimbs was significantly decreased in dysplastic dogs compared with the sound dogs (Table II). This difference was found significant for just one parameter: the maximal pressure ($p=2$ 10-5 N/inch^2). The surface remained not significantly changed. The post-operative maximal pressure and surface of stance did not appear significantly different from sound one.

For the intra dog comparison, there was no statistical difference between pre-operative and post-operative gait (Table II). Pressure and paw surface during stance were not different before and after surgery. Broadly gait seemed unchanged, however if each dog was considered individually, gait analysis allowed to show gait modification. An increase of the stance report on forelimbs was found for four dogs (figure 2). However, a decrease of the stance on forelimbs was found for one dog and the last three dogs presented slight modifications. But these modifications were not statistically significant.

Discussion

Joint capsule denervation is a procedure performed since many years on animals and human beings [1, 3, 4, 7]. It was described as an interesting procedure to manage chronic joint pain of the hand, elbow or hip [10]. In horses, denervation was used to treat lameness associated with digital pain.

To pretend to limit pain, clinicians need firstly to have anatomical knowledge about innervation of the joint. Concerning the canine hip joint, the macroscopic innervation is already described [5, 8]. After a complete dissection, GASSE *et al.* [5] concluded that branches of 4 nerves innervated the joint capsule: the gluteal cranial nerve, sciatic nerve, femoral nerve and obturator nerve innervating the cranio-lateral, caudo-lateral, medial and caudal aspect respectively. STASZYK and GASSE [18] performed a subsequent study to map capsular innervation by acetyl-cholinesterase staining. It was found that individual intracapsular nerve fibres were related to distinguishable areas of the joint capsule (segmental innervation)

	Mean speed (cm/s)		**Maximal pressure (% on the hindlimbs)**		**Stance surface (% on the hindlimbs)**	
	Pre-operative	**Post-operative**	**Pre-operative**	**Post-operative**	**Pre-operative**	**Post-operative**
Sound dog	-	-	**43.50**	**43.50**	**40.50**	**40.50**
Dog 1	193.00	132.00 ± 25.46	33.89	48.89 ± 4.93	38.31	46.40 ± 3.20
Dog 2	113.80 ± 21.63	137.67 ± 4.51	33.96 ± 1.03	30.15 ± 3.54	38.55 ± 2.04	36.49 ± 1.92
Dog 3	107.50 ± 37.48	157.67 ± 27.54	29.60 ± 4.27	44.90 ± 13.01	35.65 ± 2.97	49.21 ± 11.95
Dog 5	117.00 ± 12.73	164.33 ± 18.23	37.73 ± 1.21	27.57 ± 4.08	39.84 ± 0.67	33.40 ± 3.84
Dog 6	122.55 ±5.56	114.33 ± 15.04	40.48 ± 3.37	38.26 ± 2.76	43.33 ± 2.47	39.21 ± 1.66
Dog 7	111.77 ± 2.08	110.50 ± 4.20	31.61 ± 1.45	34.43 ± 1.17	36.27 ± 1.39	41.10 ± 1.84
Dog 8	160.67 ± 59.50	106.33 ± 8.74	41.43 ± 1.57	42.85 ± 0.28	43.60 ± 0.79	44.44 ± 0.71
Dog 9	127.67 ± 35.12	205.33 ± 15.53	25.99 ± 5.25	35.00 ± 5.00	35.71 ± 3.48	39.94 ± 4.14
Mean ± SD	**126.10 ± 47.83**	**139.20 ± 19.34**	**35.75 ± 4.3***	**39.45 ± 8.47**	**39.90 ± 4.02**	**42.33 ± 7.09**

** Difference found significant with a $P < 0.05$..*

TABLE II: Pre-operative and post-operative results of gait analysis. Results are expressed as mean ± standard deviation (SD) when several trials can be performed per dog (the dog 4 was unable to practice a regular walk and was excluded of the analysis). For hind limb pressure and hind limb surface, data displayed below correspond to the distribution on hind limbs presented as a percentage.

FIGURE II: View of the Dog n°2 preoperatively (left picture) and 3 months postoperatively. Note the modifications of weight-bearing: three months postoperatively, the dog was comfortable and did not report its weight on its forelimbs.

but some indirect nerve fibres were also found emerging out of muscles surrounding the joint. An individual variation was described but a symmetrical innervation pattern was observed.

Denervation of the craniodorsal aspect of the joint capsule in canine hip dysplasia aims to improve comfort of patients. Due to decreased pain and increased activity, pelvic and femoral muscles are strengthened which leads to more stability of the incongruent, dysplastic joint [7]. During the last decade, some retrospective studies have been published [7, 9, 10, 12, 17]. The clinical outcome of the different studies appeared interesting according to patient improvement. Around 90% of the cases displayed decreased pain and an increase of activity 3 or 4 months postoperatively at re-examination [7, 9, 10, 12]. Most of the owners appeared satisfied and 95.7% would have chosen this procedure again [10]. Apart from the high success rate, hip denervation has the advantage of being technically a very simple procedure which can be carried out on dogs of any age. No sophisticated instrumentation is needed. The low cost of denervation is another main advantage. Compared to hip denervation, long-term drug treatment is more expensive and presents more side effects [10]. Considering the simplicity of the method and the lack of serious complications, KINZEL *et al*. [10] concluded that denervation of the hip joint capsule is the therapy of choice for hip dysplasia. In the case of treatment failure of this primary palliative technique, a more extensive surgery (femoral head and neck osteotomy, total hip replacement) should be considered.

LINCOLN *et al*. [12] were the first to evaluate results of denervation using clinical and objective gait analysis. They performed an evaluation of gait improvement according to measurement of peak vertical forces and vertical impulse using force plate analysis. As in other studies, sensory denervation of the hip joint capsule resulted in clinically significant improvement in lameness and coxofemoral pain but was not associated to improvement in the measured ground reaction forces. Instead of measuring one limb loading several times, the GAITRite® gait analysis system allows simultaneous measurement of spatiotemporal parameters and pressure of the 4 limbs at the same time during the consecutive strides of the walk on the 4.3 m long walkway [11, 19]. This system allowed extensive data collection, in the same experimental conditions. Each stance of each four paws was analysed in the same walk using successive strides in a single test. Moreover with this device, shift of weight bearing during the walk can be evaluated by analysing the ratio fore/hind limbs and symmetry of limbs (peak of pressure, number of activated sensors). In normal dogs, 60% of weight bearing is supported [12, 19] by forelimbs. During hindlimb lameness, stance is known to be reported more acutely on forelimbs [2, 14-16, 20]. Cruciate ligament rupture and hip dysplasia are associated to a shift of weight bearing on forelimbs [14, 20]. Similar observations were done in this study, a significant forelimb stance report was found for the pressure distribution in preoperative gait analysis. Paw surface also seemed to present such variation but without any significant statistical difference. The disparity in shape and weight of the included animals could explain the large variation observed for this parameter, which might jeopardize the significance, statistical studies being not processed individually. Denervation was supposed to decrease this shift by limiting pain. As LINCOLN *et al*., the present results suggest that most of the dogs are clinically improved without any significant effect on weight bearing during ambulation [12]: 4 dogs improved their stance on hindlimbs, one dog worsened and three dogs presented irrelevant changes. The clinically improvement found in our study could be correlated with the increase of mean speed test between pre and post-operative sessions. Unfortunately no statistical evidence supported it. Recently, LISTER *et al*. [13] published results in direct contrast to previous studies. Only 50% of the dogs were considered improved but they grouped physical examination, gait evaluation and owners opinion. They also demonstrated that the limb, which was not treated, was worst after 3 months while the operated limb improved or remained unchanged.

The authors recognise the shortcomings of the study. Due to the absence of randomised, prospective, long-term clinical studies with control groups matched for age, breed, sex and environmental factors, the clinical effect of a procedure is difficult to determine [6]. Long-term follow-up could be interesting to evaluate osteoarthritis development and rate of recurrence. KINZEL *et al*. [9] published a 10 years follow-up of denervation. They performed 269 hip denervations and follow-up was carried out over a period of 2 months to 10 years. No case of re-innervation was diagnosed.

As a conclusion, the hip denervation is a simple procedure without any major complication. Sensory denervation seems to increase comfort and possibly range of motion during ambulation. Despite this improvement, no effect during weight bearing was demonstrated according to the gait analysis. Denervation of the hip joint capsule remains a therapy of choice to manage hip dysplasia on account of improvement of activity level and decrease of pain and lameness.

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