RESEARCH PAPER | Veterinary Science | Volume : 5 | Issue : 3 | March 2015 | ISSN - 2249-555X

Kinetic Gait Analysis of Dogs Submitted to Bilateral Perineal Hernia Repair Using Semitendinosus Muscle Transposition

KEYWORDS: Perineal hernia, semitendinosus muscle transposition, peak vertical force, dog, kinetic analysis and locomotion.

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ABSTRACT *Perineal hernias have high postoperativecomplication and recurrence rates. Several surgical procedures have been described for perineal hernia correction, among which semitendinosus muscle transposition (SMT). This study was designed to evaluate weight bearing duringlocomotion of dogs submitted to SMT for correction of bilateral perineal hernia.Eleven dogs were submitted to pressure platform gait analysis prior to and 30, 60 and 90 days after surgery; vertical force was measured in operated and contralateral limbs. Interlimb (longitudinal) and intralimb comparisons of mean peak vertical force (PVF), vertical impulse (VI) and stance phase duration (SP) were performed using repeated measures ANOVA and the paired T testrespectively ($p < 0.05$). Lack of significant differences in mean PVF, VI and SP between operated and contralateral limbs suggests SMT dos not affect locomotion in dogs.*

INTRODUCTION

Perineal hernias are characterized bycaudal displacement of pelvic or abdominal organs into the perineal area following rupture of the pelvic diaphragm. The condition is secondary to weakening and separation of pelvic diaphragm muscles and fasciae (Anderson, et al. 1998). Several surgical procedures are indicated for perineal herniorrhaphy, such as isolated or combined internal obturator and superficial gluteal muscle transposition (Anderson et al., 1998; Bellenger& Canfield., 2003). Recurrence is one of the most common postoperative complications;semitendinosus muscletransposition (SMT) istherefore recommended in association with common herniorrhaphy procedures for increased support (Chambers & Rawlings, 1991; Mortari et al., 2005).

Despite intact contracting ability, the semitendinosus muscle undergoes atrophic and functional changes following transposition. Lack of ischiotibial motor function estimated by clinical assessment or goniometry does not seem to cause lameness in the affected pelvic limb (Mortari et al., 2005). However, kinetic quantification of weight bearing and gaitparameters in dogs submitted to SMT has not been performed to date.

Investigation of vertical forces and stance phase duration using pressure platform kinetic analysis is the gold standard for gait and weight bearing analysis in dogs (Fanchon&Grandjean, 2007; Besancom et al., 2003; Oosterlinck et al., 2011). This study was designed to demonstrate normal gait and weight bearing assuming lack of impact of SMT on pelvic limb motor function in operated dogs.

MATERIALS AND METHODS

Procedures in this study were approved by the Animal Ethics Committee of the School of Veterinary Medicine and Animal Science, University of São Paulo (FMVZ-USP; protocol No. 1138/2007); informed owner consent was obtained in all cases.

Animals -

Eleven dogs affected with bilateral perineal herniaand submitted to SMT were selected for the study, regardless of breed, body weight and age. Surgical procedures were performed at the Small Animal Surgery Department (VCI) of the FMVZ-USP Veterinary Hospital (HOVET-FMVZ-USP). All dogs were submitted to clinical examination, radiographic and ultrasonographic assessment, laboratory workup and electrocardiography prior to surgery.

Kinetic analysis -

Patients were submitted to pressure platform (Tekscan®)[1]gait assessment prior to and 30, 60 and 90 days following surgery.

In the system employed, passages are recorded as dogs walk on the pressure platform; peak vertical force (PVF), vertical impulse (VI),stance phase duration (SP), velocity and acceleration data are then analyzed using dedicated software[2]. Aforementioned parameters were recorded and analyzed in pelvic and thoracic limbs in this study. A known (standard)weight was employed for pressure platform calibration.

Dogs were held from the left side and walked in a straight lineby their respective owners. Velocity was defined as the stride length/stance phase ratio;maximum acceptable accelerationcorresponded to 0.1 m/s^2.

Five valid passages (e.g. Figure 2A) out of a maximum of 20 repetitions were considered for vertical force graph generation (Figure 2B). Peak vertical force and VI values (Newtons and N.s respectively) were expressed as percentage of body weight; SP was recorded in seconds.

Procedures -
Dogs were submitted to general inhalation anesthesia with isofluorane following preoperative food and water withdrawal (12 and six hours respectively) and evaluation by the HOVET Anesthesia Carte Team. Individual patient needs were accounted for.

Dogs were positioned in sternal recumbentwiththe pelviclimbs hanging over the end of the surgical table and the tail tied in a craniodorsal direction(Figure 1A). The internal obturator muscle was elevated and anchored to the coccygeal and external anal sphincter muscles prior to SMT (Figure 1B). Muscle transposition was performed from the limb contralateral to the more severely affected side. The semitendinosus muscle was carefully dissected and the caudal distal femoral artery ligated with 4-0 monolylon suture (Figure1C). The muscle was then measured (Figure 1D) and transected; the degree of shortening was recorded. Following closure of the stump with interrupted cruciate sutures,the remaining portion of the muscle flapwas transposed to the perianal area (Figures 1E and 1F) and anchored to the repaired pelvic diaphragm muscles for increased support. Subcutaneous tissues and skin were closed with 3-0 nylon suture in a simple interrupted pattern (Figure 1G).

Operated limbs were bandaged and sutures removed 15 days after surgery (Figure 1H). Postoperative therapy consisted of antimicrobials, anti-inflammatory and analgesic drugs as needed. Patients were clinically reassessed on postoperative days 3, 7, 15, 30, 60 and 90.

Statistical Analysis -
Normality of data was confirmed using the Kolmogorov-Smirnov test. Repeated measures ANOVA was employed for analysis of longitudinal operated limb data (0, 30, 60 and 90 days). Transversal analysis between operated and contralateral limbs was performed using the paired T test. The level of significance was set at 5%.

RESULTS
The samplestudied comprised exclusively male dogs aged 10.5±2.3 years and weighing 18.5±12.5 kg. Mean pre- and post-transection semitendinosus muscle length corresponded to 12.2 and 8.8 cm respectively.

Kinetic parameters evaluated in this trial (mean PVF, VI and SP, and respective p valuesobtained in paired T tests comparing operated and contralateral limbs) are given in Table 1. No significant differences were detectedbetween operated and contralateral limbs (p> 0.05). Mean velocity (m/s) did not differ significantly between different time points (1.0±0.21, 1.1±0.13, 1.2±0.20 and 1.2 ±0.22; p> 0.05).

DISCUSSION
Semitendinosus muscle transposition is indicated for correction of chronic and recurrent perineal hernias in dogs (Chamber & Rawlings, 1991). Unilateral perineal hernias are far more common in the canine species (Matera et al 1981; Raiser, 1994); however, patients presenting with bilateral hernias associatedwith ventral compromise are more likely to require complementary support procedures such as SMT (Mortari, 2004), and were therefore selected for this study

The semitendinosus muscle is responsible for knee flexion and hip extension. Despite ample evidence of the roleof this muscle in pelvic limb flexion-extension motion dynamics, the hypothesis that SMT does not compromise locomotion was based on previous studies reportingno lameness or loss of range of motion in dogs submitted to SMT (Chambers & Rawlings, 1991; Mortari, 2004). Subjective numerical or visual lameness scoring systems based on clinical assessment are known to be less accurate and reliable compared to kinetic analysis (Quinn et al. 2007).

Kinetic analysis (Budsberg, Verstrat, and Souttas-Litle, 1987) is thought to be the gold standard for lameness diagnosis and gait assessment. Accurate quantification of lameness-related gait parameters such as PVF and VI (Fanchon&Grandjean, 2007) can be achievedusing pressure platforms (Gillete& Angle, 2008).

Pressure platforms are low cost, portable pieces of equipment. Evaluation of complete gait cycles in a single passage allows fast data collection with similar level of reliability to force plates (Besacon et al., 2003; Gillete& Angle, 2008). The present study used high resolution systemof pressure platform containing large numbers of sensors per area which are capable to provide detailed quantification of weight bearing on different areas of limb pads in healthy dogs (Souza et al., 2013), as well as in dogs affected with orthopedic conditions (Souza et al., 2014).

Minor asymmetries have been reported in healthydogs at the trot (Colborne et al., 2011). Dogs in this trial were not asymmetrical; gait assessment at walking speed may have minimized dominance of one limb over the other.

Limited sample size precluded selection of a single dog breed and led to high body weight variation in this study. Subtle differences in weight distribution may be masked by breed and/or body weight effects, despite mitigation of potential errors by expression of gait analysis parameters as percentage of body weight (Bertram et al. 2000; Lee et al. 2004; Voss et al., 2011).

That being said, high sensitivity (up to 92%) of PVF for lameness detection (Fanchon et al.,2006) minimizes the possibility of errors andsupports previous evidences (Chambers &Rawlings, 1991; Mortari, 2004) as well as the hypothesis tested in this trial, that SMT has no negative impacts on gait in operated dogs. Peak vertical force is thought to be the most accurate parameter for lameness detection (Fanchon&Grandjean, 2007); however, similar VI and SP between operated and contralateral pelvic limbs were also documented in this study.

Electromyographic studies revealed preservation of ischiotibial nerve conduction velocity, latency, amplitude and action potential.Absence of action potential in the transposed semitendinosus muscle was documented in 5 and 6 out of 10 patients (15 and 60 days respectively),with recov-

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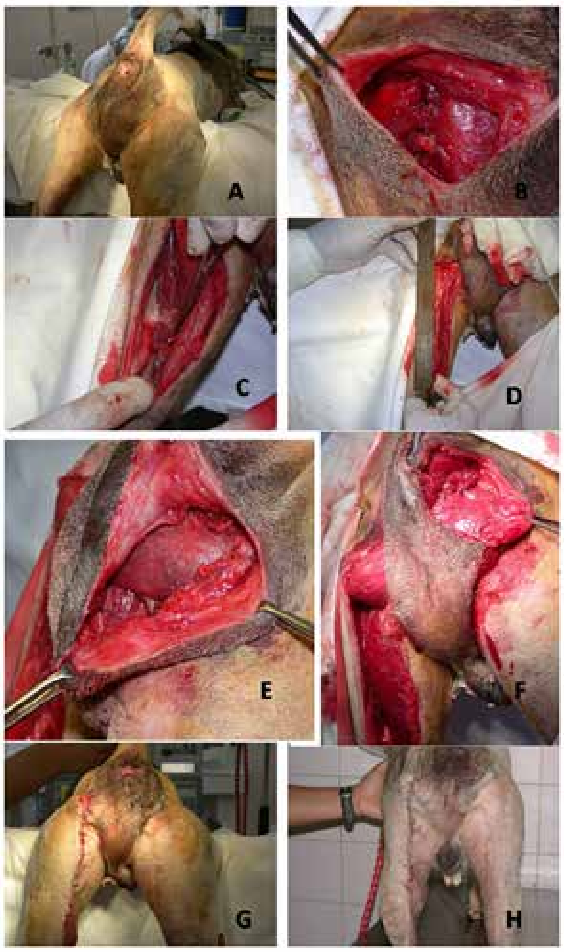
ery in 90 days. Reduced area, atrophy and mild fibrosis of the transposed semitendinosus muscle (histomorphometric analysis) were demonstrated in the same study. Yet, no lameness was reported (Mortari et al., 2005).

CONCLUSION

Results of this study support the hypothesis that SMT has no negative impacts on weight bearing in operated dogs, as demonstrated by quantitative kinetic analysis using pressure platform based on peak vertical force, vertical impulse and stance phase duration.



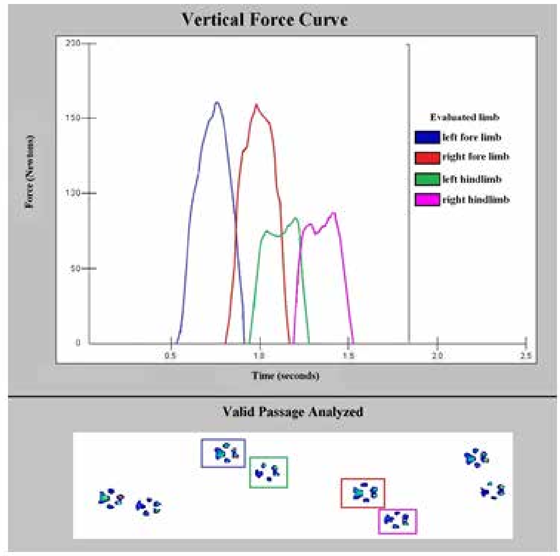


Figure 2 – Kinetic analysis; Dog No2 - Passage recorded 30 days following surgery. A - Valid passage analysis using analytic frames. B- Vertical force–time graph: Vertical force curves in thoracic and pelvic limbsover time.

Table 1 –Mean (±SD) peak vertical force and vertical impulse (expressed as percentage of body weight).

	Time (days)	Ipsilateral TL	Contralateral TL	Operated PL	Contralateral PL	Pvalue
PVF-%BW	0	51.0 ± 10.5	51.9 ± 9.9	30.5± 3.6	30.3± 2.7	0.8542
	30	49.9 ± 7.5	51.1 ± 7.9	28.9± 3.7	30.0± 2.8	0.1227
	60	50.6 ± 10.9	51.5 ± 9.8	29.6 ± 4.0	29.0 ± 3.1	0.7079
	90	51.3 ± 9.3	51.6± 8.9	29.5± 4.0	30.2 ± 2.3	0.9539
VI - %BW*s	0	22.7 ± 4.0	23.8 ± 3.8	14.8± 2.5	14.8 ± 2.4	0.8900
	30	24.8 ± 5.2	24.8 ± 5.4	14.4 ± 2.2	14.4 ± 2.4	0.7566
	60	22.3 ± 4.6	23.4 ± 4.2	13.8 ± 2.6	13.4 ± 1.9	0.4237
	90	22.4 ± 4.4	22.6 ± 4.0	14.1 ± 2.8	14.0 ± 2.6	0.6463
TA - s	0	0.35±0.13	0.35±0.13	0.36±0.14	0.36±0.14	0.6130
	30	0.33±0.10	0.33±0.10	0.32±0.10	0.32±0.10	0.5121
	60	0.31±0.12	0.30±0.12	0.30±0.13	0.30±0.13	0.4714
	90	0.29±0.11	0.29±0.11	0.29±0.11	0.29±0.11	0.5059

TL: Thoracic limb. PL: Pelvic limb. P value:comparisons between operated and contralateral limbs (paired-T test). Time 0: preoperative values.

Volume : 5 | Issue : 3 | March 2015 | ISSN - 2249-555X

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