Radial shock wave therapy in dogs with hip osteoarthritis

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Summary

Objective: The study aims were to evaluate the effects of radial shock wave therapy (RSWT) in dogs with hip osteoarthritis (OA) using clinical assessment and kinetic analysis.

Methods: Thirty dogs diagnosed with bilateral hip OA and 30 healthy dogs were used. In OA dogs, one limb was randomly selected for treatment with RSWT while the contralateral limb served as an untreated control. Dogs were evaluated while walking on a pressure walkway. Peak vertical force (PVF) and vertical impulse (VI) were documented; symmetry index (SI) was also calculated. Blinded clinical evaluation was performed using a visual analogue scale (VAS). Owner perception data regarding levels of physical activity were also collected. The RSWT protocol (2000 pulses, 10 Hz, 2–3.4 bars) consisted of three weekly treatment sessions (days 1, 8 and 16). Follow-up data were collected 30, 60 and 90 days after the first session. Data were compared between time points, groups and limbs pairs.

Results: At the end of the experimental period, mean PVF and VI values had increased (25.9 to 27.6%BW and 2.1 to 12.7%BW × s respectively) in treated limbs, with no significant differences in control limbs; SI values suggest improvement. Mean PVF and VI remained lower in the treated compared to the healthy group following treatment. The VAS scores suggested improvement in pain and lameness in treated dogs. Owner perception data suggested improved levels of physical activity following treatment.

Conclusions and clinical significance: Outcomes of this study suggested beneficial effects of RSWT in dogs with hip osteoarthritis.

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Introduction

Radial shock wave therapy (RSWT) has been recently introduced for treatment of canine osteoarthritis. Shock wave therapy has beneficial chondroprotective effects such as decreased metalloproteinase and increased type II collagen synthesis, anabolism, and increased blood flow to the subchondral bone (1). Pain alleviation through nociceptive inhibition or selective denervation of unmyelinated fibres has also been reported (2-4). Based on these beneficial effects, improvement of clinical signs following shock wave therapy has been suggested in objective quantitative kinetic as well as clinical studies (5-8). Despite research efforts, specific recommendations for RSWT application (energy density, number of pulses, and number of sessions) remain unclear (9).

Energy levels of 1.2 mJ/mm^2 applied via a high-energy lithotripsy machine have been tested and are thought to be safe for laboratory animal cartilage tissue, despite reports of haematoma formation (10). Maximal energy levels previously employed in canine studies corresponded to 2 bar (approximately 0.1 mJ/mm^2) and were therefore low. Orthopaedic shock wave therapy machines can reach pressures as high as 5 bar; dose dependent effects have been demonstrated in treatment of chronic calcifying tendinitis of the shoulder in humans, with better outcomes following applications of intermediate (0.3 mJ/mm^2) compared to low (0.1 mJ/mm^2) energy levels (11). Testing of different RSWT protocols is recommended (9).

Kinetic analysis is vital for accurate canine gait analysis and has been employed to assess the effects of shock wave therapy in dogs (5, 6, 12, 13). However, the use of kinetic analysis to assess the effects of RSWT protocols with working pressures above 2 bars in dogs affected with hip dysplasia and osteoarthritis has not been reported to date. This study was based on the premise that the RSWT protocol selected (maximum working pressure of 3.4 bars, or 0.3 mJ/mm^2) for treatment of hip joint osteoarthritis would improve locomotion and reduce signs of pain in dogs.

Methods

Safety care, sample and selection criteria

This project was approved by the Bioethics Committee of the Faculty of Veterinary Medicine and Animal Science of the University of São Paulo (FMVZ/USP). Informed owner consent was obtained in all cases.

Thirty dogs that were diagnosed with bilateral hip osteoarthritis were used. One limb was randomly selected for treatment with RSWT while the contralateral limb served as an untreated control. Proper randomization ensured a 50% chance of treating the right or the left limb. Treated and control limbs were compared on day 0 (pre-treatment), and 30, 60 and 90 days after the first RSWT session. These dogs composed the treated group in this study.

The following inclusion criteria were adopted: dogs of large breeds weighing more than 20 kg and aged over two years, radiographic diagnosis of bilateral hip dysplasia and osteoarthritis according to *Fédération Cynologique Internationale* guidelines and by consensus among three experienced examiners (ANAS, JMM, MPF), clinical signs of lameness and mild to severe pain on hyperextension of the hip joint. Severity of osteoarthritis was subjectively graded as mild, moderate or severe by the same examiners.

Exclusion criteria were as follows: medication with corticosteroids or non-steroidal anti-inflammatory drugs over the last four and two weeks respectively, medication with chondroprotective drugs over the last 60 days, dogs subject to orthopaedic surgery, dogs suffering from concurrent orthopaedic or systemic diseases, pregnancy, pelvic tumours or wounds, cardiopathic patients or patients not eligible for sedation, and patients with neurological symptoms.

Thirty healthy dogs with a similar age and body weight to dogs in the treated group, with normal hip joint radiographs and no clinical signs of hip dysplasia or osteoarthritis, were included in the study. Different from the treated group dogs, these dogs were used in a single trial to provide a reference for normality (i.e. healthy dogs) of kinetic parameters.

Radial shock wave therapy protocol

A radial 15 mm pneumatic generator[a] was used. Radial shock wave therapy was applied in three weekly sessions on days 1, 8 and 16. In total, 2000 pulses at 10 Hz were delivered in each session in the following sequence: 200 pulses at 2.0 bars pressure, 400 pulses at 2.6 bars, 600 pulses at 3.0 bars, and 800 pulses at 3.4 bars pressure. The initial pressure of 2.0 bars is equivalent to an energy density of 0.1 mJ/mm^2 and the final pressure of 3.4 bars is equivalent to 0.3 mJ/mm^2 and the rise in pressures through the treatment session was based on the manufacturer's recommendation. Each session was identical in protocol.

Radial shock wave therapy application required clipping of the hip area. Clipping was performed bilaterally to assure blind evaluation. Following application of conductive gel, the probe was positioned cranial to the greater trochanter of the femur, dorsal to the biceps femoris and ventral to the gluteal muscles. The probe was angled 90 degrees to the hip for determination of the orthogonal plane and to provide access to the target area following tipping of the probe; a probe angulation of 90 degrees to the skin was intended to provide access to the hip joint centre. Pressure was maintained and the probe slightly tilted in a cranial direction to minimize the distance between the skin and hip joint centre. Light slow circular movements were performed to encompass all structures in the affected joint. Pain, haematoma formation and petechial haemorrhage can result from superficial tissue damage following radial shock wave application; therefore the treated area was inspected and palpated by the operator (ANAS) upon conclusion of the procedure and anaesthetic recovery.

Anaesthetic protocol

Anaesthesia was performed by the Anaesthesia Care Team of the FMVZ/USP. The anaesthetic protocol was tailored to individual needs based on clinical examination, complete blood count, and serum biochemistry (urea, creatinine, alanine aminotransferase and alkaline phosphatase levels). Animals aged over six years were evaluated by electrocardiography.

Following food and water withdrawal (12 and 8 hours respectively), eligible patients were sedated with acepromazine (0.05 mg/kg IM) and meperidine (2 mg/kg IM) and anaesthetized with propofol (5 mg/kg IV). A tracheal tube was passed and patients were maintained with isoflurane as necessary (approximately 5 minutes per session).

Clinical assessment

A blinded examiner (MPF; veterinary surgeon) performed the clinical assessment of dogs in this study. Clinical assessment was based on a 0–10 Visual Analogue Scale (VAS) where 0 corresponded to absence of clinical signs and 10 to the worst possible pain, lameness and crepitus. Pain and crepitus were assessed during hip joint flexion/extension and limb abduction and adduction. Lameness evaluation was performed during kinetic gait analysis, with the examiner blinded to the computer monitor. The blinded examiner in this study was blind to patient data regarding treated limb or follow-up phase.

Data on previous treatments were obtained from the clinical history of each patient. Comprehensive clinical examination was conducted to assure satisfaction of the selected inclusion and exclusion criteria.

Owner perception

Owner perception before and after treatment was graded using a 0–10 VAS where 0 corresponded to poor quality of life with severe gait impairment and 10 to excellent quality of life with unimpaired pain-free locomotion.

Kinetic analysis

A 1.5 x 0.5 m pressure sensitive walkway[b] equipped with a series of three instrumented plates containing a total of 6864 sensors and connected to a dedicated computer was used for kinetic analysis. Sensors were calibrated according to a known standard weight before each session.

Five valid trials were evaluated out of a maximum of 20 consecutive passages recorded. Passages started two metres before the walkway. Trials were considered valid

a MasterPuls® MP200: Storz Medical, Tägerwilen, Switzerland

b 7100 QL Virtual Sensor 3 Mat System: Tekscan Inc., South Boston, MA, USA

PVF (days)		Ipsilateral TL	Contralateral TL	Treated PL	Contralateral PL	p-value	SI of PFV
Treated group	0	50.9 ± 4.1	52.2 ± 6.5	25.9^{a} ± 5.3	28.7^{a} ± 6.3	<0.001	18.^{4a} ± 15.0
	30	50.1 ± 8.9	51.5 ± 8.9	26.7^{a} ± 6.4	27.3^{b} ± 7.0	0.1985	16.1^{ab} ± 13.8
	60	50.6 ± 7.2	51.0 ± 8.4	27.7^{b} ± 6.7	28.1^{ab} ± 7.0	0.3693	14.1^{ab} ± 12.4
	90	50.3 ± 7.5	51.2 ± 8.3	27.6^{b} ± 6.1	27.7^{ab} ± 6.3	0.9539	12.4^{b} ± 9.3
Healthy group		Right TL	Left TL	Right PL	Left PL		
		50.7 ± 5.5	50.3 ± 5.6	30.4^{c} ± 5.1	30.6^{c} ± 5.1	0.6185	4.5^{c} ± 3.2

Table 1 Mean (± SD) peak vertical force (PVF) and respective symmetry index (SI) values, (expressed as percentage of body weight).

Means with different superscript letters in the same column differ significantly; p <0.05. SD: standard deviation; TL: thoracic limb; PL: pelvic limb; p-value: comparison between treated and contralateral pelvic limbs (paired t-test); SI = symmetry index; PVF = peak vertical force.

when dogs walked in a straight line without sidestepping or deviation of the head, at a velocity between 1.0 and 1.3 m/s ± 0.1 m/s^2 acceleration.

Velocity and acceleration were calculated using software[c,d]. Velocity was defined as stride length divided by the duration of the stride cycle. Acceleration was estimated based on the difference between initial and final velocity divided by time. For increased reliability, only stance phases with a variation of ± 0.01 seconds between consecutive foot strikes were considered.

Dogs were allowed four passages (acclimatization) before data collection. Only full stride cycles recorded in the middle of the platform by the same operator (ANAS) were used in the analysis. Trials were performed before physical examination and before routine daily physical activities to avoid potential interferences. All dogs were walked on the pressure walkway by their respective owners; owners always stood on the left side of the dog.

Peak vertical force (PVF, Newtons) and vertical impulse (VI, N × s) were calculated from the vertical force curve generated automatically by the software[c]; PVF and VI values expressed as a percentage of body weight (% BW) were recorded at each foot strike.

The symmetry index (SI) of PVF was also calculated for the pelvic limbs (SI = 200 × [higher PFV - lower PVF]/[higher PFV + lower PVF]). A SI value of 200 indicates a dog that is non-weight bearing on one side. The symmetry index (SI) was calculated for every five valid passages; consecutive left and right foot strikes were taken into account.

c I-scan 5.231: Tekscan Inc., South Boston, MA, USA
d Microsoft Office Excel 2007: Microsoft Corporation, Redmond, WA, USA

Table 2 Mean (±SD) of vertical impulse values (expressed as percentage of body weight × second).

VI (days)		Ipsilateral TL	Contralateral TL	Treated PL	Contralateral PL	p-value
Treated group	0	24.2 ± 4.4	24.9 ± 5.0	12.1^{a} ± 2.5	13.9^{a} ± 2.8	<0.001
	30	24.2 ± 4.5	24.8 ± 5.1	13.0^{b} ± 2.5	13.8^{a} ± 2.8	<0.005
	60	23.6 ± 4.5	24.3 ± 5.1	12.9^{ab} ± 3.1	13.7^{a} ± 3.1	<0.005
	90	23.0 ± 5.3	23.8 ± 5.8	12.7^{ab} ± 2.7	13.2^{b} ± 2.8	<0.05
Healthy group		Right TL	Left TL	Right PL	Left PL	
		25.9 ± 4.8	25.7 ± 4.7	14.8^{c} ± 2.8	14.6^{c} ± 2.7	0.8060

Means with different superscript letters in the same column differ significantly; p <0.05. SD: standard deviation; TL: thoracic limb; PL: pelvic limb; p-value: comparison between treated and contralateral pelvic limbs (paired t-test).

Statistical analysis

Normal distribution of the data was confirmed using the Kolmogorov-Smirnov test. The paired t-test was employed for cross-sectional comparisons (i.e. treated vs. control limbs). Longitudinal comparisons (i.e. comparisons between treated or control limbs) were performed with repeated measures ANOVA and the post-hoc Tukey test. Intergroup comparisons were made using the paired t-test. Subjective data were not normally distributed and were analysed using the Friedman test and the post-hoc Dunn's test. Owner perception data were compared using the paired Wilcoxon test. The level of significance was set at five percent (p <0.05).

Results

The age and body weights of the treated (6 ± 2.8 years, 33.2 ± 6.5 kg) and healthy (5.6 ± 3.3 years, 34.5 ± 7.2 kg) dogs did not differ significantly (p >0.05). According with *Fédération Cynologique Internationale* guidelines, severity of hip dysplasia was mild (n = 2), moderate (n = 11), and severe (n = 17 cases). All patients had a history of unresponsiveness or recurrence following treatment with non-steroidal anti-inflammatory drugs, analgesics and chondroprotective drugs coupled with controlled physical activity and were therefore considered to be refractory to conservative therapy.

Peak vertical force, SI, VI and clinical data (means ± SD) are reported in ▶Table 1, ▶Table 2 and ▶Table 3 respectively.

Table 3 Mean (±SD) of subjective parameters graded by a blinded examiner using a visual analogue scale.

Parameter	Treated limb				Contralateral limb			
	Pre- and post-treatment (number of days)							
	0	30	60	90	0	30	60	90
Pain	6.4 ± 1.9[a]	5.5 ± 1.6[b]	5.3 ± 1.5[bc]	5.0 ± 1.8[c]	5.4 ± 2[b]	5.2 ± 1.7[bc]	5.1 ± 1.7[bc]	5.0 ± 1.7[bc]
Lameness	4.1 ± 1.6[a]	3.7 ± 1.7[a]	3.5 ± 1.5[ab]	3.0 ± 1.4[b]	3.9 ± 1.6[a]	3.8 ± 1.7[a]	3.7 ± 1.4[a]	3.5 ± 1.4[ab]
Crepitus	4.1 ± 1.9a	4.0 ± 2.0[a]	4.1 ± 1.6[a]	4.0 ± 1.9[a]	3.9 ± 1.9[a]	4.0 ± 2.0[a]	4.2 ± 1.6[a]	3.9 ± 1.9[a]

Means with different superscript letters in the same row differ significantly; $p < 0.05$. SD: standard deviation.

Peak vertical force values differed between treated and control limbs at the beginning of the experimental period; however these differences were no longer present at the end of the follow-up period due to increase in PVF values in treated limbs. Symmetry indices at 90 days suggested improved symmetry in the treated group; however, SI values were still lower than those documented in healthy dogs. Vertical impulse values were also initially different and these differences persisted to the end of the follow-up period despite a mild increase in mean VI values.

With respect to subjective clinical data, pain scores were initially different, but no longer differed at the end of the follow-up period due to improvement in both limbs. Lameness did not differ significantly between treated and control limbs at the beginning of the experimental period, and improved in both limbs following treatment. Crepitus remained unchanged throughout the follow-up period. Dog owners reported improvements in the quality of life and level of physical activity of the dogs studied following treatment.

Mean and standard deviations of owner perception scores at the time points considered corresponded to 6.2 ± 0.9, 7.2 ± 0.8, 7.7 ± 1.0 and 8.0 ± 0.9 (days 0, 30, 60 and 90 respectively; 0 <30 <60 = 90, $p < 0.05$).

All dogs completed the treatment protocol. Six patients had petechiae at the treatment site, but no signs of pain were reported by the operator immediately after treatment. Blind assessment (7 days after the last session) did not reveal superficial signs, therefore the examiner remained blind. Mean velocity was 1.1 m/s (± 0.1m/s) and acceleration ± 0.1m/s^2 in both groups. Mean pelvic limb weight bearing times in the treated group (0.48 ± 0.07 sec) and the healthy group (0.49 ± 0.05 sec) did not differ significantly ($p > 0.05$).

Discussion

Shock wave therapy is thought to have indirect biological effects (14–16). In this trial, RSWT was employed to reproduce the clinical benefits reported in other studies in animals (5, 6). However, a higher level of energy (up to 3.4 bars) was used. Also, a larger sample and objective parameters were selected and only one pelvic limb was treated, while the contralateral limb served as its own untreated control. In some human orthopaedic conditions, 3.4 bar doses are known to be more effective than the 2 bar doses employed in veterinary medicine and in other osteoarthritis treatment studies (5, 6). Laboratory animal data support the safety of energy flux densities employed in this study for cartilage tissue (10). Having said that, this trial was aimed at testing the value of a RSWT protocol using higher energy doses than those previously tested in dogs, albeit below energy levels (0.6 mJ/mm^2) known to cause tendon tissue damage in laboratory animals (17).

Small sample size limited the number of groups in our study; therefore comparison of different protocols was not feasible. Although the protocol tested in our study cannot be assumed to be superior to others, we believe it has value in treatment of dogs suffering from hip osteoarthritis. Samples including over 400 dogs would be required to obtain enough sample power (above 80%) to strongly support the value of small differences documented in this study in the face of a potential placebo effect (18). Placebo effect is known to impact PVF in dogs with osteoarthritis and may mimic well-documented beneficial effects of drugs such as carprofen and tramadol (18).

Although shock waves indirectly benefit tissue repair, high energy levels may cause cellular damage (17, 19–21). However, no signs of discomfort or deterioration of the condition were noted following treatment using intermediate energy levels (0.18 to 0.3 mJ/mm^2). Petechial haemorrhage may also occur following shock wave therapy and it was observed in some dogs in this trial. Despite potential benefits, patients suffering from coagulation disorders should not be treated with shock waves (22, 23). Only minor adverse effects were detected in our study. Still, superficial tissues are expected to receive larger energy doses than deeper structures such as the coxofemoral joint. Energy intensity is known to decrease in proportion to the square of the distance from the source in radial shock wave therapy; therefore, effective doses may lead to increased incidence of minor adverse effects (9, 14).

Besides tissue repair, RSWT is employed for pain control. In this study, the degree of pain decreased in most patients. Different theories have been proposed to explain the pain relief promoted by shock waves (2, 24). Cutaneous denervation has been reported in laboratory animals, but whether these analgesic effects would be amplified at higher intensities is not known (3, 4). Excessive energy flux density may cause cell damage and is therefore contraindicated in delicate structures such as blood vessels and nerves (25). Intermediate doses, capable of enhancing the analgesic and reparative effects of shock waves without causing damage have not been determined to date (23).

Radial shock wave therapy does not restore articular congruence; hence, the bio-

mechanics of the hip joint remains abnormal in dogs with hip osteoarthritis following application of RSWT. However, well established analgesic and reparative effects support the use of shock waves as a supplementary treatment for dysplastic dogs (2, 4, 16). Clinical improvements following shock wave therapy have been reported and are supported by the results of this study, despite the higher energy levels employed (6, 8, 26, 27). Therefore, RSWT may be an alternative to surgical treatment in cases refractory to conventional conservative therapy.

One important caveat when interpreting outcomes of this study is that our sample may have been biased towards cases with moderate to severe degenerative changes in the hip joint according to the *Fédération Cynologique Internationale* hip dysplasia grading system. Matching degrees of hip dysplasia and osteoarthritis possibly reflected dog age range (i.e., exclusively middle aged dogs). Although this precludes discussions on the potential effects of a similar RSWT protocol in cases of mild hip osteoarthritis, reparative effects of shock waves reported in studies using animal models of induced osteoarthritis suggest shock wave therapy may be even more beneficial in less severe cases (16).

The number of pulses and sessions are an important consideration when choosing RSWT protocols. Studies in laboratory animals have reported beneficial effects of shock wave therapy protocols involving 800 pulses delivered in one or two weekly sessions, while three weekly sessions would be potentially harmful (1). This study involved one session per week for three consecutive weeks, with 2000 pulses delivered per session. A similar RSWT protocol with respect to number of pulses and sessions had been previously tested in dogs affected with hip osteoarthritis, with no adverse effects, and was therefore adopted in this trial (6). In accordance with the results of that study, no major adverse effects were documented in the dogs treated (6).

Conformation differences related to breed such as body weight and size do impact vertical ground reaction forces; hence, biases may be thus introduced in kinetic analysis when different groups of animals are compared. Dogs with similar body weight were therefore used in this study, with the contralateral limb serving as control (28-34).

Mean PVF has been reported to differ between limbs in dogs with hip osteoarthritis, but differences should no longer be present following treatment (6, 35). In an effort to minimize variations in data collection, dogs in this study were handled by their respective owners, trial velocity was controlled based on stride distances and weight bearing times, acceleration was maintained within acceptable ranges of variation and passages started 2 metres before the walkway (29, 36-41). For the sake of reliability, these factors must be controlled in kinetic studies involving longitudinal and cross-sectional comparisons between limbs (13).

Mean PVF values have been shown to change little following treatment of HD, with minor differences between healthy and dysplastic dogs in contrast with conditions such cranial cruciate ligament rupture, where mean PVF differences may be as large as 15.7 % BW (42). Even in unilateral cases of HD, mean PVF may differ by no more than three percent compared to the non-dysplastic limb (43).

The degree of HD may impact PVF in dogs of the same breed (44). Mean PVF differences between healthy and dysplastic dogs in this sample were similar to values reported in that other study (2 and 4% of BW; mild and severe HD respectively) (44).

In a study with 47 dogs submitted to total hip replacement, mean PVF increased by 3.65% BW 12 months following surgery, while an increase of 2.22% BW in mean PVF was documented in 10 dogs three months following treatment by denervation (45, 46). Mean PVF increase (1.7% BW) was lower in this study. However, differences regarding the method of kinetic analysis employed should be taken into account and sample limitations were previously mentioned to avoid misinterpretation based on scientific evidence level.

The SI was able to evaluate unilateral low grade lameness in a sample comprised of 34% of bilaterally affected patients (47). Similar means in treated and untreated limbs in this study translated into decreased SI. Therefore disparity remained high following treatment compared to healthy dogs, but improved with respect to baseline values, suggesting at least some beneficial effects of treatment. In this study, SI was based on differences between pelvic limbs over consecutive gait cycles; this may have translated into higher SI values compared to calculation based on overall PVF means, which tend to differ less (▶Table 1). It is important to mention that the use of the contralateral limb as a control may not be ideal due to potential load redistribution. Load redistribution has been reported but has been not supported by a second study (48, 49). Also, outcomes of this study suggest RSWT was able to produce significant improvements while being far less invasive.

Other conservative treatment modalities based on the administration of non-steroidal anti-inflammatory medications such as carprofen have been shown to increase mean PVF by 1.2% BW (46). However, adverse effects associated with the long-term use of non-steroidal anti-inflammatory medications have been well documented and clinical sings of HD tend to recur following discontinuation of treatment (50, 51).

Vertical impulse increased over time in treated but not in contralateral limbs, balancing out initially different baseline VI values. Small variations in stance time may produce these effects. Vertical impulse is a less accurate parameter compared to PVF and the lack of differences in stance time may have reflected type II errors due to the small sample size in this study (13). Differences between VI values of healthy and dysplastic dogs were evident in this sample, although this finding may be inconsistent (44).

Qualitative (subjective) clinical data in this study support improvements in pain and lameness reported in previous studies (7, 27). Despite randomization efforts, baseline values of objective and subjective (pain) parameters differed at time point 0 in this trial. These discrepancies are believed to have reflected asymmetries commonly observed in dogs with hip dysplasia (2, 46). Values did not differ significantly in the contralateral (untreated) limb (repeated measures analysis), which therefore served as a reliable control.

With respect to lameness, subjective numerical or visual scores are not as accurate as kinetic analysis, which enables quantification of weight bearing parameters and may be able to measure subtle differences in dysplastic dogs (52, 53). These dogs may show variations of three to four degrees in hip and knee extension on kinematic analysis (54). Variations of such small degree may explain why initial differences in PVF values and pain on physical examination could not be detected during clinical lameness evaluation in this study.

Placebo effect is known to affect owner judgment; therefore VAS data have inherent limitations and must be interpreted with caution (55). Small sample size precluded inclusion of a placebo group in this study. Visual scale based owner and clinician assessment is poorly correlated with objective gait analysis data and is primarily indicated in unilateral conditions (56). Data derived from subjective assessment cannot be assumed to reflect true improvement in treated limbs and should be seen rather as a measurable description of owner and clinician perception.

Anatomical limitations preclude precise location of the site of pain in dogs with hip osteoarthritis, given only general hip joint pain can be detected by palpation. Hence, RSWT was applied using circular movements in an effort to encompass all structures in the affected joints. Dogs in this study were anaesthetized to avoid potential discomfort due to the higher energy flux density employed compared to previous studies (5, 6).

Conclusion

The qualitative and quantitative results presented suggest beneficial effects of RSWT in dogs suffering from hip osteoarthritis. Further studies are warranted to determine the ideal RSWT protocol and other potential indications for this treatment modality.

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Conflict of interest

This authors of this study did not report any conflict of interests

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