Short Communication

Effect of interferential current therapy on ground reaction force in dogs with hip osteoarthritis: A randomized placebo controlled cross-over clinical trial

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Abstract

The aim of this study was to evaluate the effect of interferential current therapy on ground reaction force and orthopedic assessment score of canine patients with hip osteoarthritis. Nine dogs that met the inclusion criteria were enrolled in this study. Each dog received 3 types of treatment: interferential current therapy (IFC), sham current therapy (SHAM), and control treatment (CTR). The order of the treatments for each dog was assigned by block randomization method. A 24-hour interval was applied between each treatment session. Subjective orthopedic assessment and objective force plate gait analysis were used as measurement of clinical improvement in this study. Lameness, articular mobility and articular pain scores as well as peak vertical force (PVF) variables were assessed prior to and post treatments. Statistical analyses revealed significant increase in PVF of the IFC group ($p<0.05$). There was a significant decrease in PVF in the CTR group ($p<0.05$). In the SHAM group, there was no significant change in PVF. There were no significant changes detected in the lameness, articular mobility and articular pain scores. Post hoc comparisons using Tukey-Kramer test demonstrated that the IFC treatment was significantly more effective than the SHAM and CTR treatments ($p<0.05$). The significant improvement in PVF of the dogs with hip osteoarthritis may be associated with pain alleviation effect of the IFC treatment. The results of this study suggest that IFC may be useful for the treatment of canine osteoarthritis

Keywords: dog, force plate, hip, interferential current, osteoarthritis

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Introduction

Electrical stimulation therapies including interferential current have been used in the pain management of musculoskeletal disorders in humans for many decades (Sluka and Walsh, 2003). The IFC machine contains 2 isolate units which can produce carrier frequency electrical currents of 2-5 kHz. The two carrier frequency currents of slightly different frequencies pass through the tissue via 2 pairs of adhesive electrodes attached to the patient's skin, subsequently interfere with one another to generate an amplitude modulated frequency (AMF) greater than or equal to 80 Hz for treating both acute and chronic lesions (Fuentes et al., 2010[a]). The results of a previous study revealed the superiority of IFC in reduction in pain and improvement in mobility when compared to other types of electrical stimulations (Rajfur et al., 2017). A veterinary report on IFC therapy in 5 canine patients with different musculoskeletal diseases has demonstrated the ability of IFC to releive pain and improve mobility (Livitchi et al., 2009). However, the validity of this study is limited because of the small sample size and the lack of a control group.

Although IFC has been well accepted as one of the important pain control modalities with minimal adverse effects in human medicine, research evidences of IFC in the treatment of canine osteoarthritis are still limited. There is still a need for well-controlled and unbiased research to prove the effectiveness of IFC therapy in canine patients. Therefore, the aim of this study was to investigate the effects of IFC in the treatment of canine hip osteoarthritis. Both objective and subjective measurements will be used to gauge the immediate treatment effect of IFC on ground reaction force and orthopedic assessment score.

Materials and Methods

Animals: The present study was conducted as a hospital-based study approved by the Institutional Animal Care and Use Committee of the Faculty of Veterinary Medicine, Kasetsart University (IACUC ID# ACKU60-VET-010). The inclusion criteria of patients were healthy canine patients with clinical evidences of hip osteoarthritis, of either gender, over 2 years of age, and weighing more than 15 kg. Upon the owners' consents, the canine patients participating in the study underwent radiographic examination to confirm the radiographic signs of hip osteoarthritis. A withdrawal period of 14 days was applied to the patients previously treated with NSAIDs, nutraceuticals or other alternative treatments before entering the study. The exclusion criteria were patients with history of neurological deficits, neuromuscular diseases and multiple joint disorders.

Study design: The current study was designed as a randomized, placebo controlled cross-over study to test the efficacy of interferential current therapy on the hind limb function of dogs suffering from hip osteoarthritis. All patients received three treatments: interferential current therapy (IFC), sham electrotherapy (SHAM) and control (CTR) treatment on separate days. The types of treatment were randomly assigned in a sequence using block randomization. The canine patients underwent subjective orthopedic assessment and objective force plate gait analysis before and after each treatment session. A washout period was set for 24 hours between treatment sessions to avoid a carryover effect. All patients were scheduled for 3 consecutive days to receive the treatments.

In the IFC group, four self-adhesive electrodes with dimension of 5 cm (Dura-stick®, Chattanooga Group Inc., Hixson, TN) were placed on the area adjacent to the hip joint (Figure 1). IFC was delivered from an electrical stimulator (Intelect® Vet, Chattanooga Group Inc., Hixson, TN). The parameters were set as follows: a carrier frequency of 4 kHz, AMF of 100 Hz, a pulse duration of 250 μsec and a phase duration of 125 μsec. Prior to treatment, optimum intensity was determined for each patient as previously described by Johnson and Tabasam (2003). Briefly, the intensity was gradually increased from its baseline to the possible highest level that the patient could tolerate without any painful sensation (Johnson and Tabasam, 2003). The SHAM group was treated by a similar protocol as previously described in the IFC group. However, this group did not receive any electrical stimulation since the electrodes were disconnected from the output channel. The dogs in the CTR treatment protocol were kept in an IFC treatment room alone without any electrodes attached to the skin.

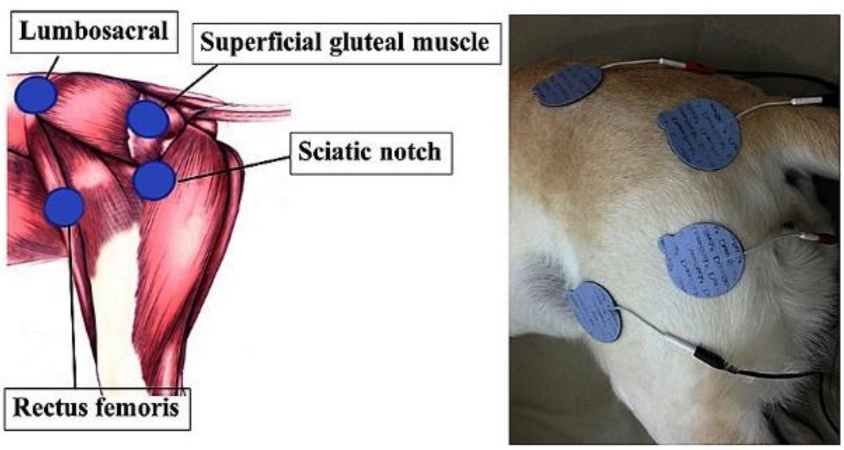

Figure 1 Schematic illustration of self-adhesive electrode placement at the lumbosacral, gluteal muscle, sciatic notch and rectus femoris adjacent to the hip area

Outcome measurement: The patients in all treatment groups were evaluated immediately before and after each treatment session. Subjective orthopedic assessments including lameness score, articular mobility score and articular pain score were evaluated by an evaluator who was blinded to the treatments (Moreau et al., 2003).

The ground reaction force in vertical direction or peak vertical force (PVF) of the affected limb before and after each treatment session was objectively evaluated by computer assisted force plate gait analysis (Figure 2). Each dog was leashed to trot on comfortable speed across the dual force platform (Model OR6, Advanced Mechanical Technology, Watertown, MA), mounted on the center of a 10-meter runway. All canine patients were leashed by the same handler throughout the study. Patient's velocities were measured by a set of 3 laser sensors positioned 2 meter apart. The velocity of each subject was controlled to a range that the difference in maximum and minimum velocities was less than 0.3 m/sec throughout the study. The ground reaction force measured by the force plate was preprocessed by proprietary software (Cortex 4.0, Motion Analysis Corporation, Santa Rosa, CA). The PVF values from the first three valid trials were normalized with respect to patient's body weight (%BW) and then averaged to use as representative data for statistical analysis. In bilateral hip osteoarthritis patients, the limb with lesser weight bearing force measured by the objective force plate gait analysis was selected for treatment assessment.

Figure 2 Schematic illustration of PVF measurement using computer assisted force plate gait analysis to measure vertical ground reaction force (F_z), craniocaudal ground reaction force (F_y) and mediolateral ground reaction force (F_x)

Statistical analysis: The treatment effects were determined using generalized linear model (NCSS 11.0.4, LLC, Kaysville, UT). Post hoc multiple comparison between the treatments was conducted using Tukey-Kramer method. A significance level was set at p value < 0.05. The pre-treatment values were compared to confirm indifferences among the groups.

Results and Discussion

Nine dogs completed the study. There were 2 males and 7 females. The breed of the patients included Golden Retrievers (n=8) and cross-breed (n=1). The mean age, body weight and body condition score were 5.33±2.18 years old, 34.09±8.44 kg and 3.89±0.6 (mean±SD), respectively. Radiographically, 7 patients in this study were diagnosed as unilateral hip osteoarthritis, whereas 2 patients were diagnosed as bilateral hip osteoarthritis. The pre-treatment values of PVF of the affected limb and their contralateral pair were 67.81±13.58 and 75.90±16.21 %BW (mean±SD), respectively.

The changes in the mean of PVF values between the pre- and post-treatments of all treatment groups as well as their 95% confidence intervals are presented in Table 1. There was a significant increase in the PVF values in the IFC treatment group (p value < 0.05), but not in the SHAM group. A significant decrease in the PVF values in the CTR group was detected in this study. The generalized linear model indicated a statistically significant treatment effect among the treatment groups (p value < 0.05). The multiple comparison using Tukey-Kramer test demonstrated statistically significant differences in the treatment effect between the IFC group and either the SHAM or CTR groups (p value < 0.05). There was no statistically significant difference between the CTR and SHAM groups (Figure 3). There were no statistically significant differences in the pre-treatment PVF values among the three groups. In this current study, a non-significant treatment effect was detected in the subjective orthopedic assessment including lameness, articular mobility and articular pain scores.

Osteoarthritis is one of the significant causes of pain and disability in the canine population. Osteoarthritic pain leads to alteration in weight bearing capacity and results in lameness and discomfort. PVF is an objective measurement widely used in orthopedic and neurological researches for decades (Foss et al., 2013; Brown et al., 2013). PVF of the affected limb will decrease with the progression of osteoarthritic condition and will increase when joint pain is treated adequately (Brown et al., 2013). The results of the current study demonstrated a significant increase in PVF value of 3.29±2.27 %BW (mean±SD) after 20 minutes of interferential therapy. The interferential current therapy was more effective than the SHAM and CTR treatments in terms of improving weight bearing capacity of the affected limb. However, this study specifically evaluated the immediate effects of IFC treatment. The prolonged effects of IFC with different treatment protocols may require further investigations.

Table 1 Mean change of PVF (%body weight) between pre- and post- treatment values of the IFC, SHAM and CTR treatment groups

Groups	Change in PVF (mean±SD)	95% Confidence interval
IFC	3.29±2.27	(1.58, 5.00)**
SHAM	-0.35±1.96	(-1.86, 1.15)
CTR	-1.84±1.99	(-3.38, -0.30)*

** significant increase in PVF ($p<0.05$)
* significant decrease in PVF ($p<0.05$)

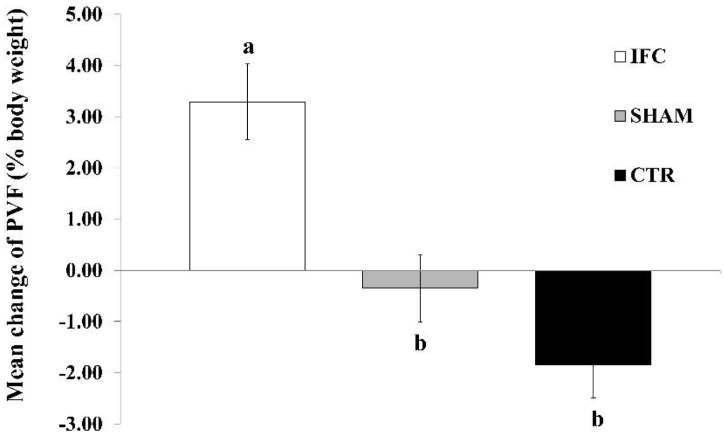

Figure 3 Mean change of PVF of the IFC, SHAM and CTR treatment groups.
[a,b] indicate that means with different superscript letters differ significantly with p value < 0.05 by Tukey-Kramer method.

The traditional lameness assessment for quadrupeds using human perception may be greatly challenged in the subtle lameness or minimal gait alteration conditions. The pain response behavior may vary among animal patients. Some animals are stoic type while others may be more sensitive to pain stimuli. Since the articular pain score used in the current study can only take particular values (0-3), visual analog scale or other pain assessment tooling such as canine brief pain inventory (CBPI) score and client-specific outcome measures (CSOM) may be more applicable than the discrete numeric scoring system in the detection of changes in pain response behavior (Sharkey, 2013).

The results from the current study are consistent with the findings from previous researches in humans. IFC is reported to be effective for the treatment of a wide spectrum of musculoskeletal diseases (Fuentes et al., 2010[b]; Moretti et al., 2011; Raifur et al., 2017). It has been proposed that IFC gave rise to the amplitude modulated frequency which can penetrate to the deep layers of the tissue. The skin and soft tissue impedance are the factors which affect the depth of penetration of the electrical currents. To overcome this resistance, high frequency current is required to allow the deep penetration. The interferential current has been widely accepted as an order of magnitude that is sufficient to defeat body tissue impedance and thus allows the IFC current to permeate into deep tissue (Fuentes et al., 2010[b]; Beatti et al., 2011). The hip joint is considered a deep target structure covered by muscle mass and joint capsule. Because of the penetration ability of IFC, the IFC current may be more appropriate for the treatment of hip osteoarthritic pain.

In conclusion, the effect of IFC in the treatment of canine hip osteoarthritis was demonstrated in this study. The increase in ground reaction force suggested that IFC could provide analgesic effect which persisted no longer than 24 hours. Further investigations into the analgesic effects by unbiased randomized controlled clinical trials are needed to explore the effective treatment protocols encompassing a wide range of pain model on IFC therapy in larger population of canine patients..

Acknowledgements

The authors would like to express our sincere thanks to the Rehabilitation Center for Small Animals, Kasetsart University Veterinary Teaching Hospital, Bangkhen campus and the Faculty of Veterinary Medicine, Kasetsart University, Bangkok, Thailand for technical and funding supports of this research. We would like to extend our appreciations to the Kasetsart University Blood Bank Unit for patient recruitment.

Our special thanks go to Dr. Chalermpol Lekcharoensuk and Dr. Marti Drum for valuable advice.

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บทคัดย่อ

ผลของการกระตุ้นไฟฟ้าชนิดอินเตอร์เฟอเรนเชียลต่อค่าแรงปฏิกิริยาจากพื้นในสุนัขที่ป่วยด้วยโรคข้อสะโพกเสื่อม: การศึกษาไขว้กลุ่มแบบสุ่มและมีกลุ่มควบคุม

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การวิจัยในครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของกระแสไฟฟ้าอินเตอร์เฟอ เรนเชียลที่มีต่อค่าแรงปฏิกิริยาจากพื้นและระดับคะแนนการประเมินทางออร์โธปิดิกส์ในสุนัขที่ป่วยด้วยโรคข้อสะโพกเสื่อม ทำการศึกษาในสุนัขป่วยด้วยโรคข้อสะโพกเสื่อมจำนวน 9 ตัว โดยสุนัขแต่ละตัวได้รับการรักษาทั้ง 3 วิธี ได้แก่ การกระตุ้นด้วยกระแสไฟฟ้าอินเตอร์เฟอเรนเชียล (IFC) การกระตุ้นด้วยกระแสไฟฟ้าหลอก (SHAM) และการพักโดยไม่ได้รับการกระตุ้นด้วยกระแสไฟฟ้า (CTR) โดยทำการสุ่มเลือกเพื่อจัดลำดับการรักษาด้วยวิธีการสุ่มตัวอย่างแบบกลุ่มย่อย การรักษาแต่ละวิธีมีระยะพักห่างกัน 24 ชั่วโมง วัดผลการเปลี่ยนแปลงด้วยคะแนนการประเมินทางออร์โธปิดิกส์ อันประกอบด้วยคะแนนประเมินภาวะขากะเผลก คะแนนประเมินการเคลื่อนไหวของข้อต่อ และคะแนนประเมินอาการเจ็บของข้อต่อร่วมกับการวัดค่าแรงปฏิกิริยาในแนวดิ่งสูงสุด (PVF) โดยทำการวัดผลก่อนและหลังการรักษา ผลการวิจัยแสดงให้เห็นว่า กลุ่ม IFC มีค่า PVF เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ในขณะที่กลุ่ม CTR มีค่า PVF ลดลงอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) และกลุ่ม SHAM ไม่พบการเปลี่ยนแปลงของค่า PVF อย่างมีนัยสำคัญทางสถิติ ส่วนคะแนนประเมินภาวะขากะเผลก การเคลื่อนไหวของข้อต่อและอาการเจ็บของข้อต่อไม่มีการเปลี่ยนแปลงอย่างมีนัยสำคัญทางสถิติ การเปรียบเทียบพหุคูณโดยวิธี Tukey-Kramer Test เพื่อพิจารณาค่า PVF พบว่า ประสิทธิภาพในการรักษาของกลุ่มที่ได้รับ IFC มีความแตกต่างจากกลุ่ม SHAM และ CTR อย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ความสามารถในการรับน้ำหนักตัวของขาที่เพิ่มขึ้นในกลุ่มที่ได้รับการรักษาด้วย IFC อาจมีความสัมพันธ์กับผลการลดปวดที่เกิดจากการกระตุ้นด้วยกระแสไฟฟ้าอินเตอร์เฟอเรนเชียล ผลการศึกษานี้แสดงถึงประสิทธิผลของกระแสไฟฟ้าอินเตอร์เฟอเรนเชียลในการรักษาโรคข้อสะโพกเสื่อมในสุนัข

คำสำคัญ: สุนัข แผ่นวัดแรงปฏิกิริยา ข้อสะโพก กระแสไฟฟ้าอินเตอร์เฟอเรนเชียล โรคข้อเสื่อม

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