A Master's Thesis

Rehabilitative Effect of Intramuscular Electrostimulation after Reconstruction of Medial Patellar Luxation in Small Sized Dog

Shinho Lee

Department of Veterinary Medicine

GRADUATE SCHOOL
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Shinho Lee

(Supervised by Professor Jongtae Cheong)

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This thesis has been examined and approved.

Youngmin Yun

Thesis director, Youngmin Yun, Prof. of college of Veterinary Medicine

Hyunjeong Park, Prof. of college of Veterinary Medicine

Jongtae Cheong

Jongtae Cheong, Prof. of college of Veterinary Medicine

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Date

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Department of Veterinary Medicine

Graduate School, Jeju National University

Abstract

Medial patellar luxation (MPL) of dog is one of the most common joint diseases. This study performed to know rehabilitative effect after reconstruction as application with intramuscular electrostimulation (IMES) on the cranial part of sartorius muscle. In this study, the 12 dogs with operated medial luxation divided into electrostimulation group (n = 8) and no electrostimulation group (n = 4) measured affected sided range of motion, muscle mass, lameness score and weight bearing for hospitalization 2 weeks. IMES group showed significant results after operation on 5th day ($p < 0.01$). Except lameness score, IMES group showed significant results on 10th day

($p < 0.05$)

As results, in small sized dog after reconstruction of MPL, IMES on the cranial part of sartorius muscle considered a great help in the initial rehabilitation.

Key words: intramuscular electrostimulation (IMES), sartorius muscle, patellar luxation, dogs

CONTENTS

Introduction

The most common diagnosis of patellar luxation is congenital or developmental medial patellar luxation (MPL) [20, 24, 25]. In small-breed dogs, luxation was medial in 99% of cases, and was lateral in only 1%; among the affected dogs, 35% were males and 65% females [1]. Most patients with patellar luxation have associated musculoskeletal abnormalities, such as medial displacement of the quadriceps muscle group, lateral torsion of the distal femur, a lateral bowing of the distal one third of the femur, femoral epiphyseal dysplasia, rotational instability of the stifle joint, or tibial deformity [6]. Femoropatellar instability, anteversion, angle of femur and inclination leading to patellar luxation are common causes of lameness in dogs [6, 17, 27].

The sartorius muscles may pay an important role in the medial tensile force which caused the patella to luxate medially. Morphometric analyses of the pelvis showed that the origin of the cranial head of the sartorius muscle lies significantly more medially in dogs with patellar luxation than in normal dogs [11, 12, 18]. This theory supported transplantation of the cranial part of the sartorius muscle for the treatment of patellar luxation [10].

In case observed intermittent episodes of a toe-touching lameness of the left pelvic limb, physical therapy was performed, including underwater treadmill exercises and electrical stimulation of the vastus lateralis muscle every 3 to 4 days for 1 month. Three months postoperatively, no lameness was seen at a walk, but occasional flexing of the limb occurred at a trot [3]. In another study, After reconstruction of MPL, the animal is restricted to short leash walks for 4 to 6 weeks, and the owner is encouraged to provide current post-operative rehabilitation protocols such as massage, passive range of motion (ROM) and swimming to regain the strength of the muscle mass [6, 24]. There were other reports for rehabilitation of MPL but there was no rehabilitation of shorten cranial part of sartorius muscle.

Electroacupuncture was first used in China during 1930s [22] . It was getting the usual, especially in the area of physical rehabilitation [21]. Electrostimulation in animals had clearly established growth, repair and remodeling of hard and soft tissues and often assumed to augment regeneration of various tissues [5]. Stimulation in any pain of neurological origin is suppression of signals through a reflex arc. In addition to functioning as an alternative method of pain relief, there is evidence that electrical stimulation encourages muscle contractions and increased blood flow to the targeted tissues [7, 8]. Lower tetanic frequencies in the range of 35~50Hz reduce muscle fatigue while still providing strong muscle contractions [16].

This study hypothesized that the dogs applied on shorten cranial part of sartorius muscle with intramuscular stimulation (IMES) help to return to activity of daily living quickly. The purpose of this study is to ascertain the rehabilitative effect of IMES treatment in small sized dog with reconstructed MPL.

Materials and Methods

Animals: The dogs were belonged to different breed, sex and weight, ranging from 9 months to 12 years old. The breeds were Maltese (n = 6), Poodle (n = 1), crossbreed (n = 1), Pomeranian (n = 1), Yorkshire Terriers (n = 2) and Shih Tzu (n = 1). There were 6 males and 6 females, 6 of which were sexually intact; of the remainder, 4 were neutered and 2 were spayed (Table 1). All the patients were symptomatic and they presented various degrees of unilateral lameness, sometimes difficulty and reluctance to walk, jump and go upstairs. None of the dogs had a previous history of trauma, and all had clinical signs associated with lameness. The animals were excluded from this study if they had any previous orthopedic disorder, including bone fracture, hip dysplasia, hip luxation and cranial cruciate ligament rupture.

Table 1. Description of Dogs with Medial Patellar Luxation

Group	No.	Breed	Sex*	Age**	Body Weight (kg)	Surgery lesion (grade)
IMES	1	Maltese	F	10 m	2.7	Left (Ⅱ)
	2	Maltese	S	5 y	3.8	Right (Ⅱ)
	3	Poodle	C	9 m	2.7	Right (Ⅰ)
	4	Crossbreed	F	5 y	6.8	Right (Ⅱ)
	5	Yorkshire Terrier	M	10 m	3.0	Right (Ⅲ)
	6	Maltese	M	5 y	4.4	Right (Ⅲ)
	7	Yorkshire Terrier	S	12 y	4.2	Right (Ⅲ)
	8	Maltese	F	5 y	4.0	Right (Ⅲ)
Control	9	Maltese	C	9 y	4.8	Left (Ⅲ)
	10	Shih Tzu	C	3 y	5.5	Left (Ⅲ)
	11	Maltese	C	3 y	4.2	Right (Ⅲ)
	12	Pomeranian	F	2 y	6.6	Left (Ⅲ)

*; F: Female, M: Male, C: Castrated, S: Spayed

**; m: month, y: year

Classifying the degree of luxation: The clinical signs associated with medial patellar luxation vary with the degree or grade of luxation (Table 2) [23]. Palpation of the stifle joint was performed on both standing animals and dogs in lateral recumbency. The patella is best located by first palpating the tibial tuberosity, then continuing in a proximal direction over the patellar ligament. One hand was placed over the patella, and the other hand was used to pick up the tibia and place the joint through range of motion. With the stifle joint in extension, the patella is isolated between the thumb and index fingers and pushed medially and laterally (Figure 1, A). The limb should be flexed and extended during examination, and the stability of the patella should be tested in all positions of the limb to determine the degree of luxation (Figure 1, B and C).

Table 2. Grading System for Medial Patellar Luxation[23]

Grade Ⅰ	The patella is positioned normally but can be luxated with slight manual pressure.
Grade Ⅱ	Spontaneous luxation occurs; however, it can reduce spontaneously or can be replaced manually
Grade Ⅲ	The patella is luxated most of the time; however it can be replaced manually
Grade Ⅳ	The patella cannot be reduced manually

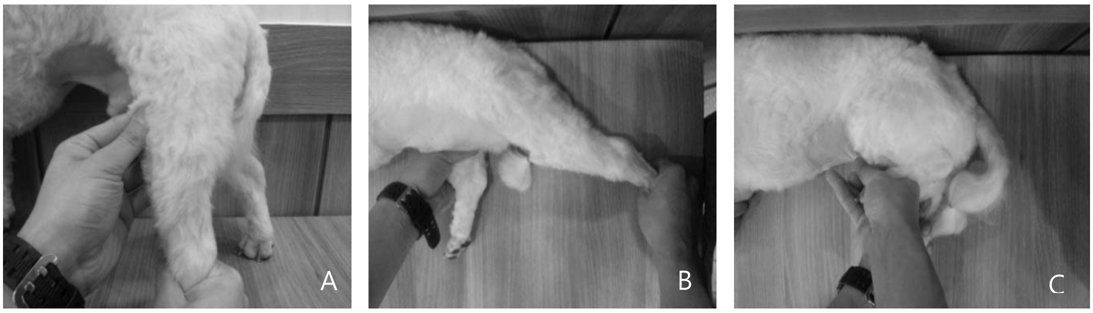

Figure 1. Classification of grade. The patella is isolated between the thumb and index fingers and pushed medially and laterally with the stifle joint in extension (A). The limb should be flexed and extended during examination, and the stability of the patella should be tested in all positions of the limb to determine the degree of luxation (B and C).

Surgical technique: Anesthetic induction was used with medetomidine (Domitor®, Pfizer, USA, 4 μg/kg), tiletamine and zolazepam (Zoletil50®, Virbac, France, 0.5 mg/kg), and tramadol (Doranjin®, Samsung pharm, Korea, 0.3 mg/kg) intravenously. And the anesthesia was maintained with isoflurane (Ifran®, Hana pharm. Korea).

The patient was placed in dorsal recumbency. The surgical procedure was selected for the treatment of patellar luxation depends on the degree of luxation, the animal's age and physical evaluation of the patella both preoperative and intraoperative. The approach of the stifle joint was craniolateral incision. Lateral imbrications, antirotational suture and wedge recession sulcoplasty were performed on grade I case. Lateral imbrications, wedge recession and tibial tuberosity transposition using k wire were accomplished in the remainder of dogs. After transposition of the tibial tuberosity and before joint capsule closure, the limb should be manipulated extensively several times through the whole range of motion with both internal and external rotation. The transposition is considered adequate if the patella cannot be displaced by manipulation of the limb alone.

Postoperative care: All dogs were rested during 14 days after operation without a Robert-Jones bandage. In IMES group, during two weeks hospitalization, the patients had intramuscular stimulation at the cranial part of sartorius muscle twice a day. Cefazolin was administered intravenously after the operation 1 day and Enrofloxacin (Baytril®-50inj. Bayer, 10 mg/kg) at a dose of 10 mg/kg was administered SC every 12 hours for 4 days. Povidone iodine topical solution 10% was used daily for application on the wound, and the skin sutures were removed on 14 days after surgery. The patients were discharged without problem.

Electrical stimulation: Dry needling was performed using stainless steel acupuncture needles (Dongbang acupuncture®, Dongbang acupuncture Inc, 0.25 mm * 30 mm) and electrical acupuncture stimulator was used for electrostimulation applications (Suzuki®, pulse generator pg-306, JAPAN). By adopting the asymmetrical biphasic spike pulse, the tissues were prevented about burns and injuries to the needle. The region was cleaned with alcohol swab and the needle was placed in the appropriate depth until the skin reaction was observed (Figure 2). The frequency of stimulation was 30 Hz and the intensity was set at a level sufficient to include muscle contraction. The current was increased from the occurrence of local muscle contractions to the peak of pain endurance for the 15~20 minutes, twice a day for hospitalization 2 weeks. At the end of the treatment, the electrostimulation was discontinued and the needles were removed. After 30~60 minutes, the animals were measured for degree of stifle joint, muscle mass, lameness score and weight bearing.

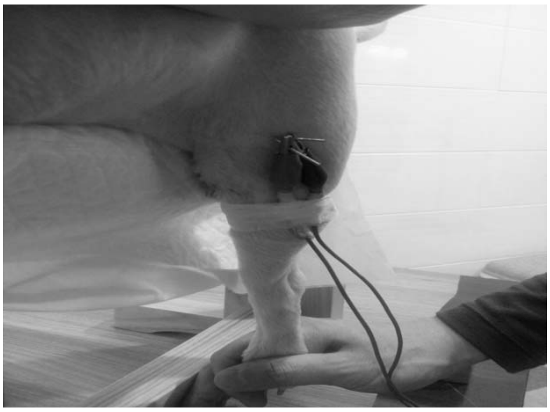

Figure 2. Electrostimulation was performed on the cranial part of sartorius muscle region

Measurement of the degree of stifle joint: The quantity of joint flexion motion is measured by using a goniometer. Measuring maximum angles may involve some discomfort. An animal experiencing discomfort is unlikely to use the limb at those angles while ambulating. Therefore measuring the comfortable ROM may be more clinically applicable. Flexion of stifle joint is measured as the angles formed by the long axis of the tibial shaft and the line joining the lateral femoral epicondyle and greater trochanter (Figure 3). To measure the comfortable ROM, the joint is slowly flexed until the first indication of discomfort, such as tensing the muscles, pulling the limb away, or turning the head slightly, is noted. A transparent plastic goniometer was used to measure the joint angles directly on skin.

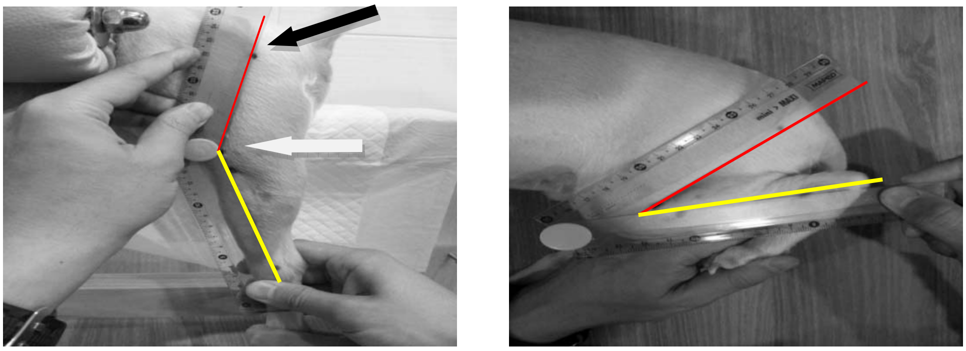

Figure 3. The measurement of the degree of stifle joint. Flexion of stifle joint is measured as the angles formed by the long axis of the tibial shaft (yellow line) and the line joining the lateral femoral epicondyle (white arrow) and greater trochanter (black arrow) (red line).

Muscle mass: A measuring tape with a spring tension device is useful in measuring limb circumference to improve consistent placement of tension on the tape when making measurements. Thigh length was determined by measuring from the tip of the greater trochanter to the distal aspect of the lateral fabella (Figure 4, A). Measurements of the sizes of the sartorius muscle were measured at the proximal edge of the patella (Figure 4, B) [16].

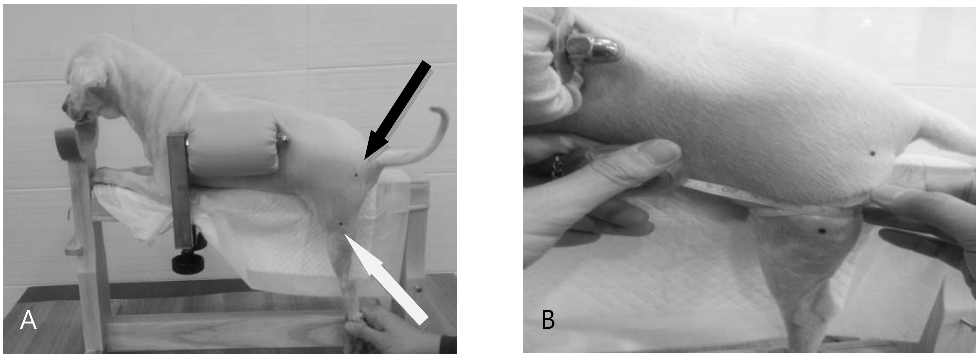

Figure 4. Measurement of muscle mass. Thigh length was determined by measuring from the tip of the greater trochanter (black arrow) to the distal aspect of the lateral fabella (white arrow) (A). A measuring tape with a spring tension device is used to measure limb circumference at the 70% location of hind limb (B).

Lameness score: The dogs were examined during movement, by two veterinarians who were blind to the grade of patellar luxation of the dogs. The dogs walked three times to evaluate lameness during movement. The lameness was evaluated by the method of Millis et al. [16] (Table 3).

Table 3. Lameness Evaluation at a Walk[16]

Score	State of Ambulation
0	Walks normally
1	Slight lameness
2	Obvious weight-bearing lameness
3	Severe weight-bearing lameness
4	Intermittent non-weight-bearing lameness
5	Continuous non-weight-bearing lameness

Measurement of weight bearing: Four body weight scales (SW-1s, CAS®) were used to evaluate each weight bearing of four limbs. The scales were placed side by side. Dogs' four limbs were on the each scale. When the dogs took front (Figure 5, A), instantaneous readings were taken from the digital displays of each scale by as assistant on the "hold" command (Figure 5, B). The dogs were tried three times to step on and off the scales in the same manner. A 10 second interval was allowed between each weight bearing trial on the scales. Three recorded value were averaged, rounded off to a whole number.

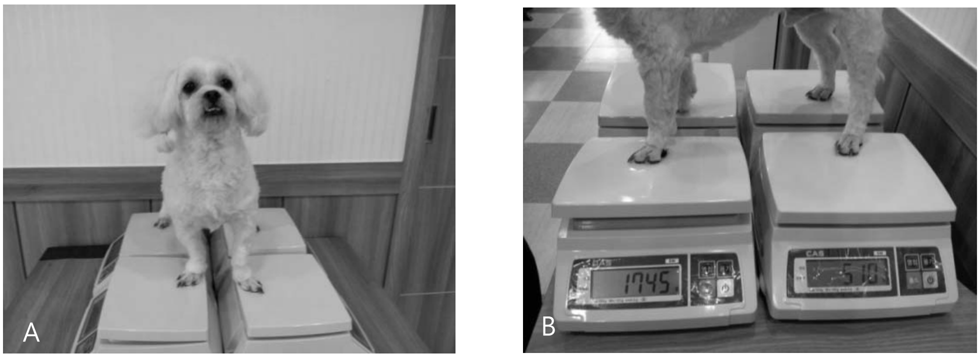

Figure 5. Measurement of weight bearing. When the dogs took front (A), each weight of dog's limb were recorded (B).

Statistical analysis: Data are presented as means ± SD. A Student`s t-test was used for statistical analysis. Differences were seemed to be statistically significant when $P<0.01$. All analyses were performed using the SPSS software (SPSS *ver.* 19.0, IBM, Chicago, IL, USA).

Results

ROM of stifle joint: Preoperatively, the result of passive ROM was 81.5±8.03° in IMES group. Passive ROMs of the stifle joint in IMES group were identified improvably on 5^{th} (94.2 ± 4.83°), 10^{th} day (102.7 ± 5.73 °), compared with the control group. The ROM in IMES group improved as 110.9 ± 3.83 on 14 days (Figure 6).

Muscle mass: For sartorius muscle atrophy that occurs with MPL, muscle masses to determine the effects of IMES were measured on 5, 10 and 14^{th} day after reconstruction of MPL. On 5^{th} day after operation, size of the muscle in IMES group increased to 2.4 ± 0.18%, but increased to 1.2 ± 0.69% in control group. On 10^{th} day, the size of the muscle mass showed an increase of 3.8 ± 0.33% in IMES group, whereas an increase of 1.87 ± 0.78% in control group. On 14^{th} day, the size of muscle in IMES group was 4.75 ± 0.55%, and in control group was 3.69 ± 0.50% (Figure 7).

Lameness score: Preoperative lameness observed in the IMES group was 3.5 ± 0.53 and in control group was 4.0 ± 0.00. On 5^{th} day, unusual changes were identified in IMES group. It showed a significant recovery of the lameness score to 2.6 ± 0.51. On 10th day, the lameness score in control group was seen to 3.3 ± 0.95, but in IMES group was seen significant recovery to 2.1 ± 0.35. Two groups were shown close to normal recovery on 14th day (Figure 8).

Weight bearing: In order to compare the weight bearing correlation of IMES group and control group, weights of the each limb were measured in both affected and non-affected hindlimb. First, in the IMES treatment group of affected hindlimb, the amount of support on 5th day had decreased to 14.4 ± 7.44%, but in the control group the amount of supported had decreased to 40.4 ± 4.03% in. On 10th day, weight bearing was increased to 54.7 ± 7.33 in the IMES group, but was increased 42.8 ± 6.94 in the control group. On 14th day, there was no significant difference between the two groups (Figure 9). Secondly, in the IMES treatment group of non-affected hindlimb, the amount of support on 5th day had decreased to 12.4 ± 11.66%, but in the control group the amount of support had decreased to 2.3 ± 2.87%. On 10th day, weight bearing was increased to 18.2 ± 26.98 in the IMES group, but 0 ± 24.08 in the control group. On 14th day, there was no significant difference between the two groups (Figure 10).

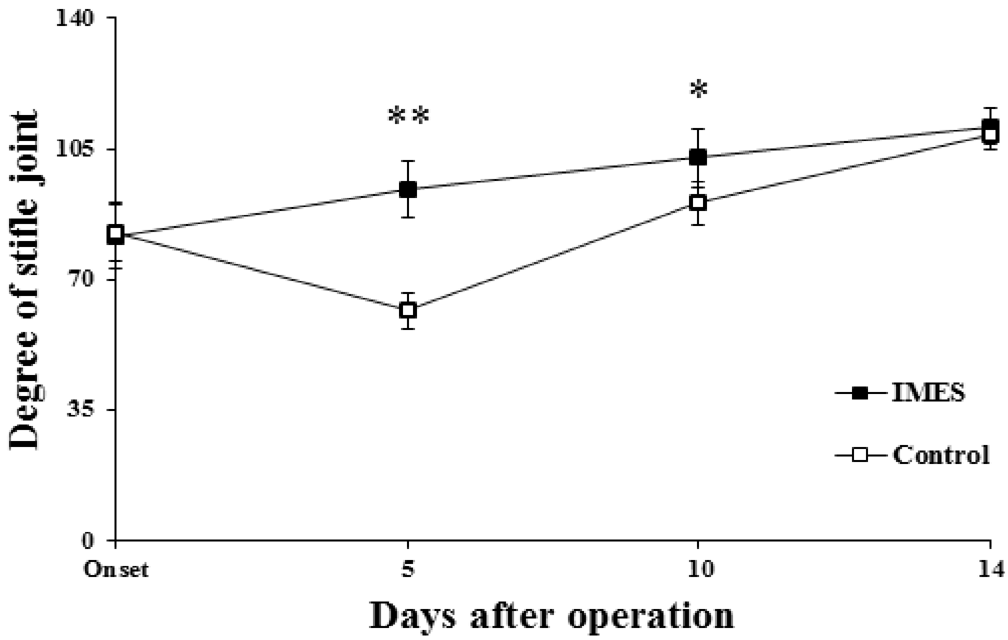

Figure 6. Comparison of the degree of stifle joint between IMES group and control group. The graph is shown significant results on 5 and 10th day. $^{*}p < 0.05$, $^{**}p < 0.01$

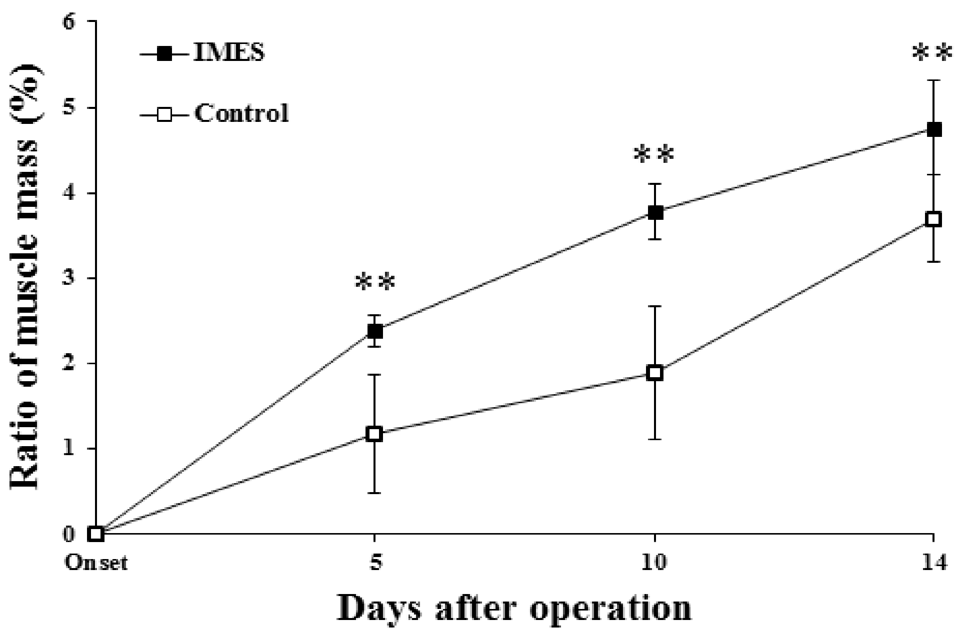

Figure 7. Comparison of the muscle mass between IMES group and control group. The graph is shown significant results on 5, 10 and 14th day. $^{**}p < 0.01$

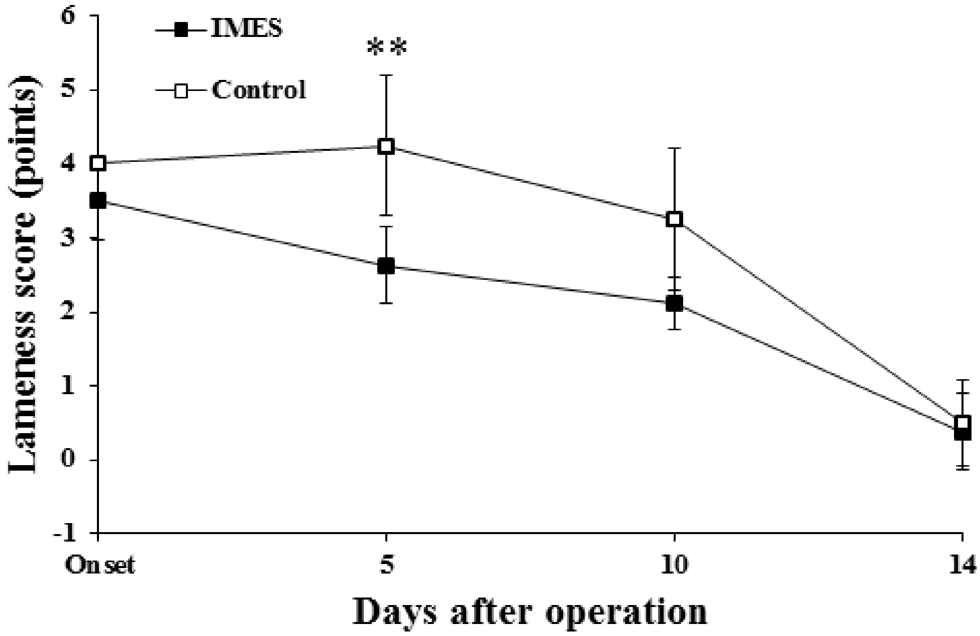

Figure 8. Comparison of the lameness score between IMES group and control group. The graph is shown significant result on 5th day. $^{**}p < 0.01$

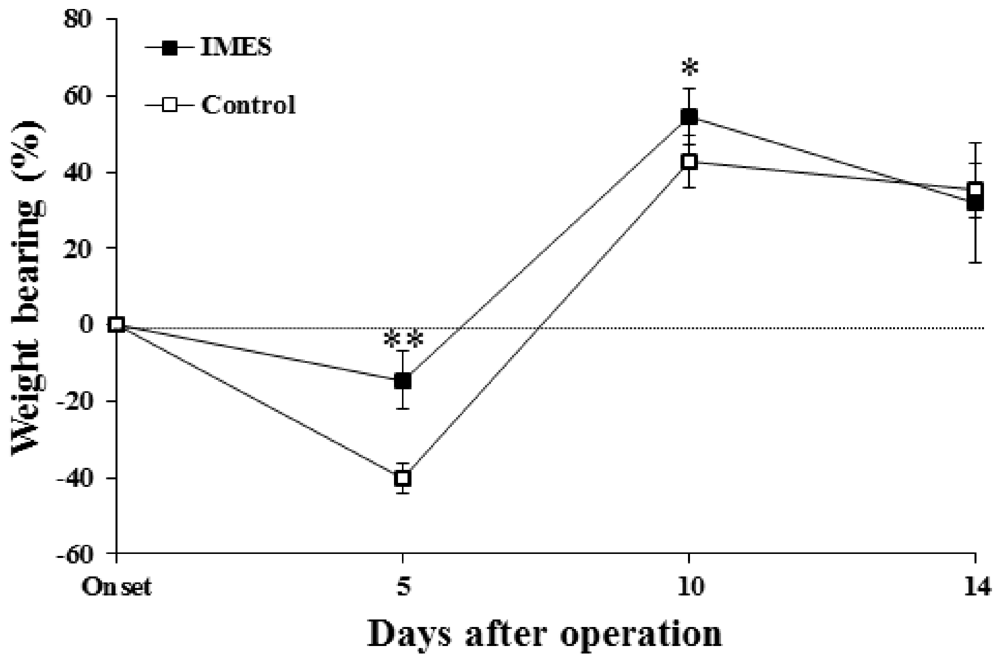

Figure 9. Comparison of the affected hindlimb weight bearing between IMES group and control group. The graph is shown significant result on 5 and 10th day. $^{*}p < 0.05$, $^{**}p < 0.01$.

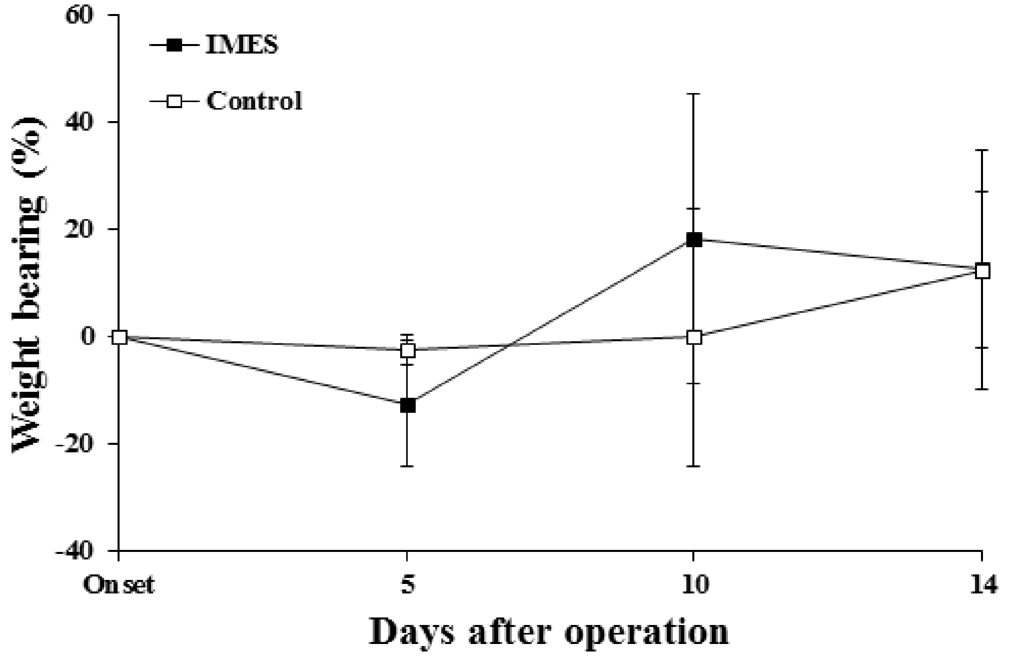

Figure 10. Comparison of the non-affected hindlimb weight bearing between IMES group and control group. The graph is shown significant results on 5 and 10^{th} day.

Discussion

Physical agents are various forms of energy, which are often called modalities and their use forms the basis of the practice for human and animal health care. Of all the physical stimuli used for therapy, that produced by a needle is the most efficacious as it is particularly capable of releasing contractures [9]. In human, IMES has immediate and mid-term efficacy in pain reduction for myofascial trigger points. He demonstrated objectively through increases in cervical and shoulder ROM and subjectively through significant decreases in visual analog scale [14]. Dogs with limited range of motion in their arthritic joints tend to perceive more pain because these joints are functioning near extreme flexion (e.g., with elbow dysplasia) or extension (e.g., with hip dysplasia) [2]. In this study, IMES group indicated improvement of ROM comparing with control group. Like reports by quoted authors, IMES reduced the shortening of sartorius muscle because spasm of muscle was decreased by electrical stimulation. In IMES group, ROM in affected limb showed the significant improvement of the up to 10 days compared in control group. After operation, there were swelling and pain around stifle joint. Swelling and pain around stifle joint as well as shortened sartorius muscle were reduced in IMES group compared in control group.

The physical effects of neuromuscular electrostimulation were to increase in muscle strength and muscle mass [4, 19]. The application of electrostimulation on the site of injury were shown not only the gross improvement on muscle mass, but also the significant improvement of muscular power in the semitendinosus and semimembranosus muscle, 45 days after surgery [15]. In this study, there is an increment of muscle mass in IMES group compared in control group at all recorded days. By the increment of the muscle mass, it is supposed IMES could induce the muscle hypertrophy by contracting muscle. If IMES apply on the sartorius muscle preoperatively, it would prevent further injury to joints and other soft tissues. In this study, better results may be obtained. However, use of a tape measure with a spring tension device may be biased by the expectations of observers. The thickness of the skin and subcutaneous tissues might be another factor affecting thigh circumference measurements.

Lameness score is a vital clinical outcome assessment tool [16]. German shepherd observed in the left stifle lameness showed the decreased flexion and extension of all joints, and the right hind leg was placed further forward than normal. He had ruptured cranial cruciate ligament [13]. Electrostimulation was felt to be able to produce the same excitatory characteristics within the motor nerve and muscle as does exercise [9, 26]. In previous researches, electrostimulation affected to the muscular re-education. In this study, the lameness score in IMES group indicated significant result on 5th day. This result means IMES group obtained more quickly muscular function than control group in the early time. If IMES is applied with exercise, the score may be improved more rapidly.

In this study, the weight bearing was improved significantly. The animals were compared to weight bearing on affected hindlimb in figure 9. IMES group had a positive effect on weight shifting into affected hindlimb on 5^{th} and 10^{th} day. Two groups showed the decrease of weight bearing on 5^{th} day. It was thought that the decreases were occurred in pain and swelling of stifle joint after operation. However, there was a significant difference in decreasing of weight bearing between two groups. The weight bearing in IMES group (14.4 ± 7.44%) was reduced much less than in control group (40.4 ± 4.03%). This difference means IMES group was more effective than control group in functional and rehabilitative aspects. On 10^{th} day, it showed actual acceleration of weight bearing as observed in figure 9. Because of the reducing of pain and swelling of stifle joint, sartorius muscle was gradually released and the degree of stifle joint was improved. Also, affected weight bearing was thought to be gradually improved. Before performing this study, although IMES was applied, the animals could not contact on the scale until 4^{th} day in preliminary experiment. Not until 5^{th} day, the dogs did not contact on the scale. The weight was measured from 5^{th} day.

In figure 10, there was no significant result in non-affected hindlimb weight bearing. However, on 5^{th} day, weight bearing of IMES group (12.4 ± 11.66%) was more decreased than that of control group (2.3 ± 2.87%). As affected hindlimb recovered, it was considered weight bearing transfer non-affected to affected hindlimb. On 10^{th} day, weight bearing of control group (0 ± 24.08) more decreased than that of IMES group (18.2 ± 26.98). It was thought that IMES was helpful for the early rehabilitation.

As results, this study showed the improvement of ROM of stifle joint, femoral muscle mass, lameness score, and weight bearing of hind limb in IMES group. Recovery of ROM and muscle strength after operation was more important than ever. As rehabilitative modality, IMES might provide the novel evidence for the effect of electrostimulation on regaining muscular ability after operation. Therefore IMES can be recommended during regaining muscular ability and re-education in other orthopedic disease. Based on the finding of improved ROM, muscle mass, lameness score, and weight bearing in this study, IMES is expected to play an important role in small animal physical therapy and rehabilitation.

Conclusion

This study performed to know rehabilitative effect after reconstruction as application with intramuscular electrostimulation (IMES) on the cranial part of sartorius muscle. In this study, the 12 dogs with operated medial luxation divided into electrostimulation group (n = 8) and no electrostimulation group (n = 4) measured affected sided range of motion, muscle mass, lameness score and weight bearing for hospitalization 2 weeks. IMES group showed significant results after operation on 5th day ($p < 0.01$). Except lameness score, IMES group showed significant results on 10th day ($p< 0.05$)

As results, in small sized dog after reconstruction of MPL, IMES on the cranial part of sartorius muscle considered a great help in the initial rehabilitation.

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국문초록

소형견의 내측 슬개골 탈구 정복술 후 근육 내 전기자극의 재활효과

이 신 호
(지도교수: 정 종 태)

제주대학교 대학원 수의학과

개의 내측 슬개골 탈구는 가장 많이 발생하는 관절 질환 중 하나로 정복 수술 후 넙다리빗근에 전기자극을 실시하여 재활효과를 관찰하기 위하여 본 연구를 수행하였다. 본 연구는 내측 슬개골 탈구가 있는 소형견 12두를 대상으로 슬개골 탈구 정복술 후에 입원 2주 동안 환측 앞쪽 넙다리빗근에 근육내 전기자극치료을 적용한 군(n=8)과 대조군(n=4)으로 나누어 관절가동범위, 근둘레, 파행 및 체중지지 정도를 측정하였다. 근육 내 전기자극을 실시한 군은 대조군에 비하여 관절가동범위, 근둘레, 파행점수 및 체중지지 등 네 가지 사항 모두 수술 후 5일에는 유의성을 나타냈고($p < 0.01$), 수술 후 10일에는 파행을 제외한 관절가동범위, 근둘레, 체중지지의 항목에서 유의성을 보였다($p < 0.05$).

이상의 결과로 볼 때, 소형견의 내측 슬개골 탈구 정복술을 실시한 후,

넙다리빗근에 전기자극을 실시하면 초기 재활치료에 도움이 많을 것으로 사료된다.

주요어: 근육 내 전기자극, 넙다리빗근, 슬개골 탈구, 개