Observation of the Effect of Ultrasound-Guided Intrafascial Heat on Ankle Dorsiflexion in Chronic Gastrocnemius Injury Contracture

Zheng Anxiang, Physician-in-charge
Li Fei, Chief Physician
Lin Sunzhi, Chief Physician
Huang Linsheng,Associate Chief Physician
Zhang Bingxian,Associate Chief Physician

Zheng Anxiang, Physician-in-charge in Image Guided Study of Chronic Pain, Department of Pain, Mindong Hospital Affiliated to Fujian Medical University, Fu'an, China. Fei Li, Chief Physician in Image Guided Study of Chronic Pain, Chongqing Fuling Central Hospital Pain Department, Fu Ling, 408000, China. Lin Sunzhi, Chief Physician in Image Guided Study of Chronic Pain, Department of Pain, Mindong Hospital Affiliated to Fujian Medical University, Fu'an, China.Huang Linsheng, Associate Chief Physician in Image Guided Study of Chronic Pain, Department of Pain, Mindong Hospital Affiliated to Fujian Medical University, Fu'an, China.Zhang Bingxian, Associate Chief Physician in Image Guided Study of Chronic Pain, Department of Pain, Mindong Hospital Affiliated to Fujian Medical University, Fu'an, China. Correspondence author: Zhang Bingxian; 978679201@qq.com

Abstract: purpose: To observe the effect of ultrasound-guided intrafascial heat on ankle dorsiflexion of chronic gastrocnemius muscle injury contracture. Methods: 90 patients with chronic gastrocnemius muscle injury contracture were selected and these patients were randomized to three random groups (n=30): Static stretching therapy (group C), ultrasound-guided intrafascial hot needle release therapy (group R1), static stretching combined with ultrasound-guided intrafascial hot needle release therapy (group R2). Ankle dorsiflexion Angle (ADA) was measured before treatment, one week one month and three Months after treatment. Quantitative ultrasonography was used to evaluate the fascicle length (FL), pinnate Angle (PA) and muscle thickness (MT) of the medial gastrocnemic muscle, and the adverse reactions were recorded. Results: After treatment, ADA and FL increased, while PA and MT decreased in the 3 groups. In R2 group, ADA and FL increased and PA and MT decreased at one week , one month and three Months after treatment, which were better than those in R1 group and C group (P<0.05); ADA, FL, PA and MT in group R1 at one week after treatment had no statistical significance compared with group C (P>0.05), but the ADA, FL and PA and MT were higher than patients in group C (P<0.05), and no serious complications occurred during the treatment. Conclusion: Ultrasound-guided intrafascial thermal needle release combined with static stretching can significantly improve the ankle dorsiflexion angle and restore muscle function in patients with chronic gastrocnemius muscle injury contracture, with definite efficacy and few adverse reactions, which is worthy of clinical promotion.

Keywords: ultrasound; fascia; intrafascial needle; gastrocnemius contracture; ankle dorsiflexion angle

Tob Regul Sci.™ 2021;7(6): 5481-5489
DOI: doi.org/10.18001/TRS.7.6.38

INTRODUCTION

Chronic gastrocnemius injury contracture is a clinical syndrome in which chronic injury to this muscle and fascia results from multiple causes, causing local ischemia,[1] aseptic inflammation, adhesions, and degeneration of the muscle and fascia, leading to a decrease in their elasticity and function, which results in a shortened state for a long time, which in turn leads to specific gait, symptoms, and signs manifested by limited dorsiflexion of the ankle joint, severely affecting the quality of life. The prevalence of chronic gastrocnemius injury contracture was found to be as high as 65% in patients with forefoot and midfoot disorders.[2] In particular, the prevalence of chronic gastrocnemius injury contracture is higher in the presence of non-traumatic diseases such as bunion and flatfoot, but the pathogenesis is unclear.[3] Studies have pointed out that improving gastrocnemius contracture is the key to treating foot and ankle disorders.[4] The current treatment methods for chronic gastrocnemius injury contracture mainly contain non-surgical and surgical treatments; non-surgical treatments, which have disadvantages such as long course and inaccurate efficacy; surgical treatments, which have a series of problems such as large trauma to patients, many postoperative complications, and difficult for patients to accept. In recent years, scholars have used intrafascial hot needling to treat chronic soft tissue damaging diseases, all with good results.[5] The current application of ultrasound technology in soft tissue treatment and assessment has been found to have the advantages of assessing degenerative fascial points and muscle trigger points,[6] and using its guided puncture has the advantages of precise target points, high safety factor, avoiding repeated punctures, and easy clinical application,[7] and itis applied in a wide range of clinical practice. The measurement of muscle fiber length, pinna angle, and muscle thickness of the medial head of the gastrocnemius muscle using quantitative ultrasound can objectively respond to changes in gastrocnemius muscle function,[8] and is also important for efficacy assessment. In contrast, few studies have been reported on the effects on myofascial length and function after intrafascial thermal needle release. In this study, we observed the effect of ultrasound-guided endofascial heat on the dorsiflexion angle of the ankle joint in chronic gastrocnemius injury contracture and the improvement of gastrocnemius muscle function using quantitative ultrasound evaluation, and achieved significant efficacy, which is reported as follows.

METHOD

General data

Ninety patients eligible for chronic gastrocnemius contracture, aged 25-75 years, with a disease duration of 12-36 months, were selected from April 2019 to May 2020 in the pain department of Min Dong Hospital, Fujian Medical University, and these patients were randomly divided into three groups: control group C (30 cases), test group R1 (30 cases) and test group R2 (30 cases).

Diagnostic criteria: Positive Silfverskiold test by clinical examination: preoperative gastrocnemius contracture diagnostic criteria: maximum passive dorsal extension of the ankle joint >10° at 90° of knee flexion, maximum passive dorsal extension of the ankle joint <0° in the knee extension position (0° in the neutral position of the ankle joint, dorsal extension is indicated by positive values, and negative values when dorsal extension cannot exceed the neutral position).[9]

Inclusion criteria: 1. Age 25 to 75 years; 2. Meeting the diagnostic criteria for gastrocnemius contracture; 3. Patients with chronic neck, shoulder, hip, knee and ankle pain, with a disease duration of 12-36 months; 4. Patients themselves were informed about this experiment and voluntarily signed the informed consent form.

Exclusion criteria:1. Pregnancy or lactation; 2. Coagulation disorders and current use of anticoagulant drugs; 3. The presence of skin infections and breaks in the lower leg; 4. Gastrocnemius contracture due to neurological diseases; 5. Serious heart, brain, liver and kidney diseases, or the presence of psychiatric disorders, or poor glycemic control, or malignant tumors; 6.

The presence of abnormal bone bodies; 7. Metal allergy.

This study was reviewed and approved by the ethics committee of Min Dong Hospital, Ningde City.

Methods

(1)Ankle dorsiflexion Angle was measured by side Angle instrument and quantitative ultrasound was used to evaluate the medial head of gastrocnemius muscle

Each patient was measured by the same professional rehabilitation therapist with the ankle dorsiflexion angle. The patient was placed supine on the treatment bed and instructed to relax the muscles of the lower limbs, and the measurement was performed by keeping the talofibular joint in a neutral position with one hand and dorsiflexing the ankle joint to the maximum with the other hand.

The linear low-frequency ultrasound probe is placed perpendicular to the long axis of the calf and the medial head of the gastrocnemius muscle is scanned to find the thickest part of the medial gastrocnemius muscle belly (usually the midpoint of the muscle belly), and the measurement point is marked on the body surface. When observing the image for measurement, the probe needs to exert minimal continuous pressure to prevent excessive deformation of the muscle fibers due to compression. The muscle fiber length is the straight line distance between the muscle fiber bundle and the tendon membrane cross; the pinna angle is the acute angle between the tendon membrane and the measured pinna muscle bundle, the probe is measured in the longitudinal direction of the muscle and the image is acquired when the pinna angle is clearly recognizable in the display, the angle can be measured with the electronic circular gauge of the ultrasound instrument. Muscle thickness is the ultrasound probe taking the thickest part of the medial gastrocnemius muscle belly for measurement and directly measuring the distance between the superficial and deep fascia.

(2) Control group C adopts static stretching treatment program

Operated by a professional rehabilitation therapist, the patient was placed supine on the treatment bed with the knee extended, instructed to relax the muscles, the therapist held the foot with both hands, instructed the patient to breathe, and slowly dorsiflexed the ankle joint during exhalation until the patient felt a strong stretching sensation in the calf and kept it still for 1 min, once a day in the morning and once in the evening, for 2 weeks as a course of treatment.

(3) Ultrasound-guided intrafascial hot needle gastrocnemius release program was used in the experimental group R1

The specific operation method of the experimental group R1: the patient was placed in prone position, the calf was fully exposed, the pillow was placed under the ankle, the starting point of the medial and lateral heads of the gastrocnemius muscle was palpated, the body surface was marked, and the point of degenerative degeneration of the gastrocnemius muscle and fascia was assessed with ultrasound (Sonosound ultrasound instrument model: Q4J6N7) before surgery (firstly, the ultrasound image range of the gastrocnemius muscle was confirmed, and important anatomical structures such as vascular nerves within the image range were confirmed to further locate scattered clumps of cloudy mixed hyperechoic signal points in normal hypoechoic muscle fibers within the gastrocnemius muscle) and marked, after routine disinfection and spreading of the towel,[10] and then confirmed the extent of the deep foci of the muscle fascia by scanning the marked points on the body surface using a linear low-frequency ultrasound probe, and then after performing satisfactory local anesthesia of the skin at the puncture site, the endothermic needle (NRZ-20R-A endothermic needle therapy instrument) was guided using an ultrasound in-plane technique Equipped with a special endothermic needle) dynamically pierced into the center of the deep myofascial lesion, puncture in place when the patient often described a strong sense of soreness and swelling, the operation process to avoid important nerves, blood vessels and other tissues, the same method to guide the endothermic needle puncture to loosen

the beginning of the medial and lateral gastrocnemius muscle and muscle belly, after successful puncture, connected to the temperature heater (endothermic needle therapy instrument: NRZ-20R-A type endothermic needle therapy instrument), 42 degrees for 20min. End needle extraction, skin disinfection, clean dressing coverage, 2 days after surgery to avoid strenuous exercise and immersion in water, once a week, 2 times a course of treatment.

(4) Experimental group R2 was combined with ultrasound-guided intrafascial thermal needle gastrocnemius release program on the basis of static stretching

Operation method: Patients were routinely stretched twice a day by professional rehabilitation therapists, with the same stretching method as group C. The course of treatment was 2 weeks, and after the first static stretching for 2 hours, intrafascial hot needle gastrocnemius release was performed, with the same release method as group R1.

Observation Index

After one week, one month and 3 months of treatment in the three groups, the ankle dorsiflexion angle, and ultrasound measurement of muscle fiber length, pinna angle and muscle thickness of the medial head of gastrocnemius muscle were measured, and the occurrence of related adverse reactions after treatment was recorded.

Statistical Methods

SPSS 23.0 software was used for statistical processing: the measurement data conforming to normal distribution and chi-square were expressed as mean ± standard deviation (x±s), one-way ANOVA was used for comparison between groups, and x^2 test was used for counting data, and $P<0.05$ was considered statistically significant difference.

RESULTS

1. There was no statistically significant difference between the three groups of patients in terms of general data such as gender, age, disease duration and location ($P>0.05$, see Table 1).

Table1
Comparison of general information of patients in the three groups (n=30, x±s)

Group	Gender（M/F）		Position(L/R)		Age(Y)	Duration(M)
C	17	13	15	15	48.77±13.245	23.87±6.616
R1	14	16	13	17	50.17±11.792	22.90±7.146
R2	15	15	16	14	47.43±15.889	23.83±7.679

Table2
Comparison of ankle dorsiflexion angles in the 3 groups (n=30, x±s)

Group	n	Before treatment	one week after treatment	one Month after treatment	three Months after treatment
C	30	-5.9±2.708	-0.57±2.555	-2.67±3.078	-0.1±3.458
R1	30	-5.37±2.646	-0.13±3.812	2.3±3.573$^{\#}$	5.4±3.597$^{\#}$
R2	30	-5.9±2.905	2.83±3.505$^{\#}$*	6.0±3.948$^{\#}$*	10.0±4.013$^{\#}$*
Fvalue		0.375	9.244	44.996	56.495

Pvalue	0.689	0.000	0.000	0.000

#P < 0.05, In contrast to the c group; *P < 0.05, In contrast to the group R1

2. Comparison of the data results of the three groups before and after treatment

(1) Patients in group R1 had better ankle dorsiflexion angles than group C at one month and three Months after treatment (P<0.05, see Table 2), while patients in group R2 had better ankle dorsiflexion angles than group C at one week , one month and three Months after treatment (P<0.05, see Table 2)

(2) Patients in the R1 and R2 groups had longer medial gastrocnemius muscle fibers measured by quantitative ultrasound at one week , one month, and three Months after treatment than in the C group (P<0.05, see Table 3).

(3) Patients in group R1 had better quantitative ultrasound gastrocnemius medial head pinna angle than group C at three Months after treatment (P<0.05, see Table 4); patients in group R2 had better quantitative ultrasound gastrocnemius medial head pinna angle than group C at one month and three Months after treatmentt (P<0.05, see Table 4)

Table3
Comparison of the length of the medial head muscle fibers of the gastrocnemius muscle by quantitative ultrasound in R1 and R2(n=30, x±s)

Group	n	Before treatment	one week after treatment	one Month after treatment	three Months after treatment
C	30	45.4±6.055	45.87±6.343	46.9±6.166	46.63±6.344
R1	30	45.4±6.981	46.9±6.283#	48.23±7.486#	49.00±7.812#
R2	30	46.8±6.059	45.97±7.233#*	51.9±6.779#*	52.73±6.918#*
Fvalue		0.482	2.585	4.309	5.708
Pvalue		0.619	0.081	0.016	0.005

#P < 0.05,In contrast to the group C; *P < 0.05, In contrast to thegroup R1

Table4
Comparison of quantitative ultrasound medial gastrocnemius head pinna angle (n=30, x±s)

Group	n	Before treatment	one week after treatment	one Month after treatment	three Months after treatment
C	30	26.47±2.488	24.23±2.542	24.57±2.459	24.5±2.739
R1	30	26.27±2.612	24.13±2.837	23.33±2.832	22.67±2.869#
R2	30	26.77±2.921	23.07±3.321	22.77±3.07#	21.77±3.213#*
Fvalue		0.265	1.473	3.244	6.703

Pvalue	0.768	0.235	0.044	0.002

#P < 0.05, In contrast to thegroup C; *P < 0.05,In contrast to the group R1

(4) Patients in groups R1 and R2 had longer quantitative ultrasound gastrocnemius medial head muscle thickness than group C at one week , one month, and three Months after treatment (P<0.05, see Table 5)

3. Summary of treatment-related adverse reactions

All patients had no serious complications during the treatment, some patients responded that there was slight itching at the puncture port within 3 days after the endothermic needling, which resolved on its own without any treatment, and all patients had no adverse reactions such as redness and swelling at the puncture port, infection and local hematoma.

DISCUSSION

Currently, researchers demonstrate that gastrocnemius myocontractures causes the formation of foot, ankle and foot ulcers;[11] however, the research on the mechanism of biomechanical compensatory damage is still unclear, so early diagnosis and early intervention are required to interrupt compensatory damage, restore foot and ankle function, reduce clinical symptoms, and significantly improve patients' quality of life. However, insufficient attention is paid to the hazards caused by gastrocnemius contracture in the current clinical treatment process, and the rate of underdiagnosis is high.

Table 5
Comparison of quantitative ultrasound gastrocnemius medial head muscle thickness (n=30, x±s)

Group	n	Before treatment	one week after treatment	one Month after treatment	three Months after treatment
Group C	30	26.03±2.498	23.87±2.636	24±2.56	23.87±2.596
GroupR1	30	26.97±2.81	24.93±2.888#	24.03±2.942#	23.23±3.025#
GroupR2	30	25.97±2.539	23.13±2.751#	22.13±2.713#*	21.50±2.224#*
Fvalue		1.367	3.226	4.716	6.483
Pvalue		0.26	0.045	0.011	0.002

#P < 0.05, In contrast to the group C; *P < 0.05, In contrast to the group R1

A large number of studies have shown the importance of static stretching in the recovery of chronic soft tissue damage. Some studies reported that the use of needle stimulation of the quadriceps agonist point combined with static stretching of the quadriceps muscle in the treatment of patellofemoral pain syndrome showed that needle stimulation of the agonist point combined with static stretching was effective in relieving pain and improving knee mobility in the short term with long-term efficacy, which is consistent with the immediate and long-term clinical efficacy of intrafascial hot needle release combined with static stretching in this study.[12]The review reported that static stretching of the ankle joint in dorsiflexion alone was used to treat gastrocnemius contracture,[13] which improved the ankle dorsiflexion angle, but had the disadvantages of long duration and inaccurate long-term effects; this is consistent with the finding that static stretching alone was effective in the near term but not in the long term in the present study. In the literature, open surgery and minimally invasive surgery were used to treat gastrocnemius contracture, and all of them significantly improved the ankle dorsiflexion angle after surgery, but there were many complications of surgery, with a statistical incidence of about 5-20%, mainly

including unsightly incisions, damage to the gastrocnemius nerve, secondary muscle atrophy, and postoperative infection, which have a great impact on patients.[14] Thus, exploring a safe, effective and less invasive method to treat this disease is the focus of research in the clinic. In a review of previous treatment methods for soft tissue damaging diseases, it is now found that there are more and more reports of intrafascial hot needling applied to treat soft tissue diseases, all with good results. For example, used endofascial thermal acupuncture to treat patients with chronic nonspecific neck pain and evaluated bilateral trapezius, cephalic splint, cephalic semispinalis, cervical semispinalis, and multifidus muscles with ultrasound, and finally found that this method significantly improved muscle elasticity and restored cervical spine mobilityreported that endothermic needling is a new method of treating chronic soft tissue damage by combining needle and heat,[15] and its needle body is thicker, mainly by needling the degeneration and adhesion points of muscles and fascia, thus improving local muscle spasm, decreasing muscle tone, reducing inflammatory response, improving vascular regeneration and blood circulation, and promoting muscle recovery and other mechanisms, so it is widely used clinically. Therefore, our study is a dependable and effective way for the treatment of chronic gastrocnemius injury contracture through the application of intrafascial hot needling.

In recent years, ultrasound has become mainstream in pain treatment applications, ultrasound application in the assessment and treatment of chronic soft tissue damage has the advantages of accurate identification of degenerated, adherent, hypertrophic fascial points, trigger points formed in muscles and inflammatory edema in muscle starting and stopping points, using ultrasound visualization to guide puncture, which can avoid important tissues such as neurovascular in puncture and guide the needle tip to the target point, with the advantages of simple clinical operation, accurate target point , high safety factor, avoiding repeated punctures, few complications, and easy acceptance by patients.[16] Quantitative ultrasound has the function of evalu ating muscles, citing its advantages of real-time, portability, no radiation, and low cost is currently widely used in clinical treatment. Filippo Molinari, et al. Rosenberg JG, et al., Bolsterlee B, et al. used quantitative ultrasound to measure structural (muscle fiber length, pinna angle, muscle thickness, etc.) parameters of skeletal muscle, which is reliable for the assessment of muscle injury and myopathic diseases;[17-19]therefore, in this study, ultrasound was used to quantify the muscle fiber length, pinna angle, and muscle thickness of the medial head of the gastrocnemius muscle. Therefore, the use of ultrasound quantification of medial gastrocnemius muscle fiber length, pinna angle and muscle thickness as an index to assess the functional recovery of the gastrocnemius is reliable. In this study, 1-week follow-up after treatment with static stretching method alone was found to improve ankle dorsiflexion angle (improvement of about 2-3° on average), medial gastrocnemius head muscle fiber length (lengthening of about 3-4%), pinna angle (reduction of about 3-5%), and muscle thickness (reduction of about 2%), but further improvement was found to be insignificant at 1-month and 3-month follow-up after treatment, which is consistent with the existence of static stretching alone. The long duration of treatment and inaccurate long-term effect are consistent with the long duration of treatment, but the improvement of ankle dorsiflexion angle, medial gastrocnemius head muscle fiber length, pinna angle, and muscle thickness was found to be insignificant at the 1-week follow-up after treatment with ultrasound-guided endothermic acupuncture alone, but the 1-month follow-up found that ankle dorsiflexion angle (average increase of about 5-8°), medial gastrocnemius head muscle fiber length (lengthening of about 5-6%), pinna angle (decrease of about 5-7%) (about 5-6%), muscle thickness (about 4% reduction), and the indicators were still further improved at the 3-month follow-up, which is related to the fact that the treatment of endofascial heat against soft tissue is the process of injury repair again, and the soft tissue repair is not complete within one week , but the soft tissue repair is complete after 1 and 3 months, so the functional recovery is more

obvious; if the two combined treatments, it was found that the degree of improvement of the indicators at the 1-week, 1-month and 3-month follow-ups was more than the other. The follow-up also found that when the ankle dorsiflexion angle improved at the same time, the patient complained that the pain in other parts of the body, such as plantar, knee, periprosthetic, lumbar, and even neck, was reduced, which may be related to the restoration of ankle function to reduce compensatory damage in other parts, so endothermic acupuncture combined with static stretching can improve muscle muscle fiber length, reduce pinna angle, reduce muscle thickness, restore gastrocnemius muscle function, improve ankle dorsiflexion angle, restore foot and ankle function, correct gait, and regulate biomechanical disorders.

In conclusion, ultrasound-guided intrafascial thermal acupuncture treatment of chronic gastrocnemius muscle damage contracture has good results in improving ankle dorsiflexion angle and restoring muscle function, and postoperative complications and adverse reactions are rare, which is worthy of clinical promotion, but the pathogenesis of chronic gastrocnemius muscle damage contracture and a series of clinical problems caused by it are not yet clear. With the development of research technology, the establishment of a perfect biomechanical model of gastrocnemius contracture to further explain the clinical problems caused will be the focus of future research; this study has a small sample size, short follow-up time and other shortcomings, long-term follow-up is still needed to observe its efficacy.

Author Declaration

The authors declare no sponsored financial sources by any organization related to tobacco production for the undertaken study.

References

1. Mores-Munoz P, De Los SRR, Brrio SP, et al. Proximal Gastrocnemius Release in the Treatment of Mechanical Metatarsalgia. *Foot and ankle international*. 2016; 37(7): 782-789.

2. Gravn-Nielsen T, Domenech-Garcia V, Herero P, et al. Pressure-induced referred pain is expanded by persistent soreness. *Pain*. 2016; 157(5): 1164-1172.

3. Kopenhver S, Embry RC, JohnWJ, et al. Effects of dry needling to the symptomatic versus control shoulder in patients with unilateral subacromial pain syndrome. *Manual therapy*. 2016; 26: 62-69.

4. Ami I, Werner S, Scicke B, et al. Comparison of Photo Optical Imaging with Musculoskeletal Ultrasound and Clinical Examination in the Assessment of Inflammatory Activity in Proximal Interphalangeal Joints in Rheumatoid Arthritis and Osteoarthritis. *The Journal of Rheumatology*, 2015; 42(9): 1595-1602.

5. Arendt-Nielsen L, Madeleine P. Accelerated muscle fatigability latent myofascial trigger points in humans. *Pain medicine*. 2012; 13(7): 957-964.

6. Pinney HST Jr, Sangeorzan BJ. The effect on ankldorsiflexin of gastrocnemius recession. *Foot Ankle Int*. 2002; 23(1): 26-29.

7. Budi Franceco, Gallasch Eugen, ChristoaMonia, et al. One minute static stretch of plantar flexor transiently increase Hreflex excitability and exert no effect on corticospinal pathways. *Experimental Physiology*. 2017; 102(8): 901-910.

8. Radfod JA, Burns Buchbinder, et al. Doe stretching increase ankle dorsiflexion range of motion A systematic review. *Br J Sports Med*. 2006; 40(10): 870-875.

9. Cychosz, Phisitkul P, Belatti, et al. Gastrocnemius recession for ankle conditions in adults: Evidence-based recommendations. *Foot Ankle Surg*. 2015; 21(2): 77-85.

10. BusquetsRos, Sanchez Judith, et al. Proximal medial gastrocnemius release: Muscle strength evaluation. *Ankle Surgery :Official Journal of the European Society of Foot and Ankle Surgeons*,2019.

11. Laura G , Valeria L, Juan PC, et al. Minimal Invasive Mid-Calf Gastrocnemius Recession: Efficacy Analysis. 2019, 4(4): 123-125.

12. Renato S, Delmany R, Cristovao GT, et al. The effect of adding myofascial techniques to an exercise programme for patients with anterior knee pain. *Journal of bodywork and movement therapies*. 2016; 20(4): 844-850.

13. DeyCN, et al. A questionnaire to identify patellofemoral pain in the community: an exploration of measurement propertie. *MusculoskeletDisord*. 2016, 31(17): 237.

14. Maggie T, Dmetrios JK, Paul EW, et al. Bedside ultrasound is a practical measurement tool for assessing quadricep muscle layer thickness. *Journal of parenteral and enteral nutrition*. 2014; 38(7): 886-890.

15. Jadhav, Riascos RF, et al. Comprehensive review of the anatomy, function, and imaging of the popliteus.*Radiographics*. 2014; 34(2): 496-513.

16. Walmsley S, Osmotherly PG, Walker CJ, et al. Power Doppler ultrasonography in the early diagnosis of primary/idiopathic adhesive capsulitis: An exploratory study. *Journal of manipulative and physiological therapeutics*. 2013; 36(7): 428-435.

17. Rostami Mohsen Kordi, RaminNoormohammadpourPardis, et al. Ultrasound assessment of trunk muscles and back flexibility. *Journal of*

back and musculoskeletal rehabilitation. 2015; 28(4): 635-644.

18. Molinari F, Caresio Acharya Advances in quantitative muscle ultrasonography using texture analysis. *Ultrasound Med Biol*. 2015; 41(9): 2520-2532.

19. Bolsterlee V, van der Helm FC, et al. Comparison of measurements of medial gastrocnemius architectural parameter from ultrasound and diffusion tensor images. 2015; 48(6): 1133-1140.