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Gastrocnemius Contracture in Patients With and Without Foot Pathology

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Abstract

Background: Several studies report performing a recession of the gastrocnemius tendon as surgical treatment of foot and ankle pain related to an isolated gastrocnemius contracture. Few report ankle range of motion using a validated measurement device or report a control group. All previous studies reporting measurements using a validated device have been small in number.

Methods: Using a previously validated device, 66 patients presenting with foot or ankle pain and 66 controls were measured for ankle range of motion and isolated gastrocnemius contractures. Clinical and goniometer measurement of ankle range of motion was also performed.

Results: The foot and ankle pain group had a mean dorsiflexion of 11.6 degrees compared with a mean of 17.2 degrees in the control group ($P < .0001$). No patients in either group had less than 15 degrees of motion with the knee flexed. The difference in dorsiflexion was less using a goniometer than using the validated device, which may be due to measurement technique and external landmarks.

Conclusion: Patients with foot and ankle pain had less ankle dorsiflexion than the control group. This is the largest study to date using a validated measurement device as well as a control group and supports the findings of previous authors.

Level of Evidence: Level II, prospective cohort study.

Keywords: isolated gastrocnemius contracture, gastrocnemius recession

Surgical gastrocnemius recession is thought to have been first described in 1913 by Vulpius and Stoffel and subsequently by Silfverskiold and others.[41,45] It has gained in popularity and has developed a growing body of evidence to support its use as a surgical treatment of various foot pathologies. Several studies support a gastrocnemius recession as surgical treatment for clinical conditions of the foot and ankle such as pediatric spastic lower extremity deformities, ulceration in diabetics, hindfoot pathologies such as plantar fasciitis, Achilles tendinopathy, midfoot arthritis, metatarsalgia, hallux valgus, and hammertoe deformities, among others.[*]

What these studies have in common is that they describe the treatment and results of an isolated gastrocnemius recession. What is not homogeneous across these studies, however, is the method of diagnosis and definition of an isolated gastrocnemius contracture. Many studies use the Silfverskiold test described for spastic conditions, whereby tension in muscles that cause action across 2 joints such as the hamstrings or the gastrocnemius can be differentiated from those that act across a single joint.[41] The definition of a gastrocnemius contracture remains controversial. While many studies have historically reported ranges of knee flexion and a definition of a contraction ranging between 0 and 25 degrees of dorsiflexion at the ankle, more recent studies define an isolated gastrocnemius contracture as a lack of ability to dorsiflex the foot past neutral, 5 degrees, or even 10 degrees.[11,13,17,21,38,40,43]

Few studies have reported dorsiflexion values in patients with foot pathology as well as a control group, and these studies have included small numbers of patients and have not been reproduced.[11] The purpose of the current study was to report the results of ankle dorsiflexion in patients with and without foot pathology as well as a control group using a validated device in a larger number of patients than has previously been reported. Our null hypothesis was that ankle dorsiflexion would be similar between patients with and without foot pathology.

[*]References 1, 2, 4, 5, 8, 11-13, 16, 18, 20, 24, 28, 30-32, 34, 35, 37, 40, 42, 43, 45.

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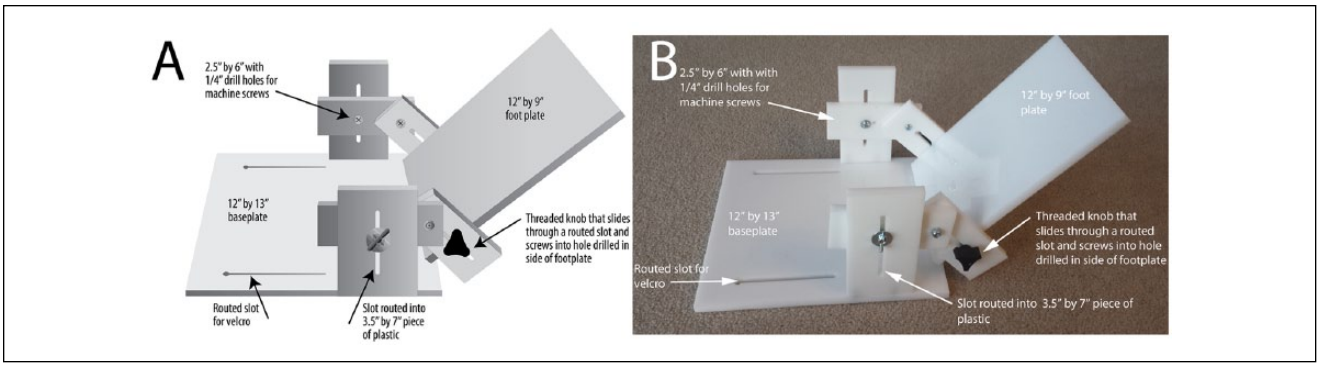

Figure 1. (A) Schematic and (B) image of the ankle range-of-motion measurement device and specifications.

Methods

Institutional review board approval was obtained and a prospective case-control study was performed. For the study group, 66 consecutive patients presenting for clinical evaluation of foot pain were prospectively recruited for the study. For the control group, 66 consecutive patients presenting to the hand surgery clinic for clinical evaluation of hand pain, or healthy controls, were prospectively recruited to participate. Inclusion criteria for both groups included those who were at least 18 years old and who consented to participate in the study. Exclusion criteria for the control group was a history of foot or ankle pain or injury.

A total of 66 consecutively enrolled patients were included in both the foot pain and control groups. The mean age of the foot and ankle population was 50 years (range, 22-81 years), and the mean age of the control group was 53 years (range, 24-80 years); these were not statistically significantly different (P = .32). Diagnoses within the foot pathology group included hallux valgus, hallux rigidus, metatarsalgia, rheumatoid forefoot deformity, midfoot arthritis, hammertoe deformities, Achilles tendinosis, and sesamoiditis, among others. There was 34 women and 32 men in the foot and ankle group compared with 38 women and 28 men in the control group. The mean body mass index (BMI) of the foot and ankle population was 31 kg/m^2 compared with 30 kg/m^2 in the control group (P = .283).There were 8 patients in the study group with inflammatory arthritis, while there was only 1 in the control population. Ten of the foot and ankle patients had diabetes compared with 4 in the control group.

Each participant underwent a physical examination, including ankle range of motion with the knee flexed and extended. Ankle range of motion was examined in 3 ways: (1) clinical estimation by the examiner, (2) goniometer, and (3) examination with a version of the Iowa Ankle Range of Motion (IAROM) device (Figure 1).[46] Care was taken during all 3 measurements to correct the hindfoot to neutral; to encourage the patients to relax the leg muscles, including the hamstring and quadriceps musculature; and to keep the hip flexed to 90 degrees.

Instrumentation

The IAROM device was originally designed to be an objective, valid, reliable, easy to assemble, inexpensive to produce, and easy to use device.[46] In addition to the details provided in Figure 1, two 6-inch-wide Velcro straps passed through the slots in the base plate, securing the leg during testing. In addition, if needed, a foam block was placed under the ankle to ensure that the applied force was acting through the center of rotation of the ankle joint. Pre- and postforce application range-of-motion measurements were obtained with a digital inclinometer with a resolution of 0.1 degrees (Checkpoint, Torrance, California), and the force was applied with a handheld dynamometer with a resolution of 0.45 kg (1 lb) (FDK 40; Wagner Instruments, Greenwich, Connecticut).

Procedure

Patients were placed in the IAROM device as described by others.[46] With the knee extended, the tibia was aligned perpendicular to the foot plate, and the axis of motion of the device was aligned with the axis of motion of the ankle.[19] This was important to ensure that the external force application moment arm was acting about the ankle joint axis to apply a standard moment. The digital inclinometer was then zeroed on the middle third of the tibial crest to serve as a consistent anatomical reference point. A moment (torque) of 25 Nm about the ankle joint was controlled by applying 111 N of force (25 lbs) perpendicular to the foot plate with the handheld force gauge at a distance of 22.5 cm from the axis of rotation of the ankle joint. Testing was performed with 2 people, one applying the force with one hand and correcting the hindfoot with the other and the other person ensuring participant relaxation and taking angular measurements (Figure 2). This sequence was performed 3 times for each study participant. All patients were subsequently examined to ensure that they had a minimum of 15 degrees of dorsiflexion with the knee flexed to a minimum of 25 degrees to

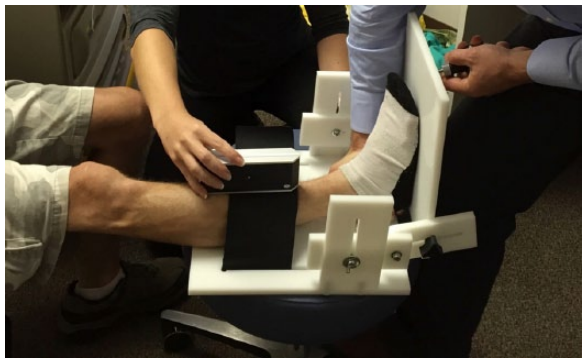

Figure 2. Clinical examination using the ankle range-of-motion device.

examine for an Achilles or ankle joint contracture with the goniometer.[6,9] In addition, goniometric ankle range of motion was assessed. For the goniometric measurement, a standard 20-cm-long goniometer with 2-degree increments was used (MDF Instruments USA, Malibu, California). Anatomical measurement landmarks were the long axis of the fibula and the fifth metatarsal bone.[27,46,47]

Statistical Analysis

Statistical analyses were performed at a .05 significance level. Population size was determined based on a power analysis with a .05 significance level and 90% power. Welch's *t* tests were used to compare variables between unequal groups, and paired Student *t* tests were used to compare variables between equal groups. Repeated-measures analysis of variance (ANOVA) was performed to assess within-subject variation in the 3 range-of-motion device measurements performed with an SAS version 9.4 (SAS Institute, Cary, North Carolina) and an α of 0.05. All statistical analysis was performed with R version 2.11.1 software (http://cran.r-project.org/).

Results

In examining the ankle range of motion, the mean dorsiflexion of the foot and ankle group was 11.6 degrees compared with 17.2 degrees in the control group ($P < .0001$) (Table 1). The range-of-motion device was used 3 times on each patient. There was no statistically significant difference between the 3 range-of-motion device measurements taken of patients either as a whole ($P = .4789$) or within each treatment group ($P = .3840$). There remained a statistically significant difference in goniometer measurement between the study group (3.6 degrees) and the control group (6.1 degrees) ($P = .02$). When looking at the clinical estimation, this difference once again was statistically significant with a mean of 3.0 degrees of dorsiflexion in the study group and 6.0 degrees in the control group ($P = .002$).

Table 1. Mean Values for Dorsiflexion.

	Dorsiflexion, deg		
Device	Study	Control	*P* Value
Range-of-motion device	11.6	17.2	<.0001
Goniometer	3.6	6.1	.02
Clinical gestalt	3.0	6.0	.002

Subgroup analysis was performed for the variables of sex (male, female), BMI (less than 30 kg/m^2, over 30 kg/m^2), and patient age (younger than 50 years, equal to or older than 50 years). Statistically significant relationships were present between the study and control groups within all 3 subgroups (Table 2). In addition, there were no statistically significant differences between these subgroups within the study and control populations.

Discussion

This is the largest study to date measuring ankle range of motion in patients with and without foot pathology using a validated device, to our knowledge. This study provides further evidence and supports previous studies demonstrating an isolated gastrocnemius contracture in some patients with foot pathology. Several previous studies have looked at the association between foot and ankle pathology and gastrocnemius contractures, but few provide objective data using a validated measurement device or a control group. In 2002, DiGiovanni et al[11] reported on gastrocnemius contracture in patients with symptomatic midfoot or forefoot pathology and also reported on a control population. They found a mean dorsiflexion of 4.5 degrees in the 28 study group patients and 13.1 degrees in the 33 control group patients. The current study supports these findings. They found that 88% of the symptomatic group had less than 10 degrees of dorsiflexion, while 44% of the control group had less than 10 degrees of dorsiflexion. To our knowledge, these results have not been reproduced. Lavery et al[29] showed that an equinus contracture of the ankle is present in over 10.3% of all patients known to have diabetes, defined as less than 0 degrees of ankle dorsiflexion, and demonstrated that these patients had significantly higher peak plantar pressures than those without the deformity and were at nearly 3 times greater risk of having elevated plantar foot pressures, which is consistent with the findings of others.[39]

The definition of an equinus contracture is agreed upon as an inability to dorsiflex through the tibiotalar joint. This is not to be confused with an isolated gastrocnemius contracture, which has been linked more recently with foot

Table 2. Subgroup Analysis.

Characteristic	Study, deg	Control, deg	*P* Value
Sex			
Males	10.3, n = 32	15.9, n = 28	.0006
Females	12.8, n = 34	18, n = 38	.0011
P value	.4669	.1946	
Body mass index, kg/m^2			
Less than 30	12.7, n = 32	17.3, n = 38	.0038
Over 30	10.6, n = 34	17, n = 28	.0002
P value	.1637	.8894	
Age, y			
Less than 50	11.7, n = 28	16.2, n = 30	.007
Over 50	11.5, n = 38	17.9, n = 36	.0001
P value	.9076	.3202	

pathology. In defining both, the clinical evaluation of ankle range of motion is critical. The axis and range of motion of the subtalar and transverse tarsal joints are hard to visualize and conceptualize yet are integrally related to sagittal foot and ankle range of motion.[22] Subtleties of hindfoot alignment and range of motion complicate the examination, including the importance of locking the hindfoot by correcting the heel into a neutral or varus position to eliminate sagittal motion through the transverse tarsal joint.

There are several methods of quantifying ankle range of motion and tension on the gastrocnemius muscle and tendon. They generally fall into 4 categories. The first is clinical examination and the experience of the performing examiner. The second is goniometry, which has challenges with determining the amount of force to apply, has shown interobserver variability and poor reliability, and does not allow the calculation of stiffness.[10,14,36,48] The third is a version of a weightbearing lunge.[7,33] The fourth is an instrumented technique with torque referencing such as that used in the current study or by others.[11] The problem with instrumented techniques is that the devices are not generally available to most clinicians.

When measuring ankle range of motion, it is important to have a standard landmark when comparing patient groups; different anatomical landmarks have been described, which confuses the results in the literature. The most frequently used are the long axis of the fibula and either the plantar surface of the foot or the axis of the fifth metatarsal bone.† In the case of the current study, the anterior crest of the tibia was used for the range-of-motion device because of its ability to be palpated and fit the inclinometer. It should be noted that the angle between the fibula and the anterior crest of the tibia is different and thus may be at least partially responsible for the discrepancy between the absolute values reported in the current study and that previously published in the literature. This is an important consideration, however, in defining an isolated gastrocnemius contracture as pathologic in terms of absolute values of ankle range of motion because different techniques will yield different absolute values.

A previous study has shown that the device used in the current study is valid and reliable for the purpose of measuring ankle range of motion. The authors showed intraclass correlation coefficient values ranging from 0.95 to 0.98 and intertester agreement values ranging from 0.90 to 0.95.[46] Our experience with this device was similar in that our measurements were reproducible. A constant-force application at a constant-moment arm eliminated subjective force application. We found the device to be very user-friendly, and we believe it was an excellent method to perform an objective measurement of the gastrocnemius complex, although a limitation of the device was that it did take 2 examiners to perform the measurement and it was not commercially available.

There are several limitations to the current study. First, the diagnosis within the foot pain group was nonhomogeneous. The benefit of a consecutive patient enrollment study design is that it prevents selection bias; a limitation is that there may be a subset of diagnoses that have a greater effect on ankle dorsiflexion than others, and the current study would be underpowered to detect these differences. These subgroups may be an area of future research. Second, the current study does not determine causation in the observed relationship between decreased ankle range of motion and associated pathology. Third, the subgroup analyses were performed retrospectively, which leaves the chance that their results are underpowered and may be an area of future research. Also, the device used in the current study was not commercially available, which makes repeatability by others a potential problem.

Conclusion

Patients with foot and ankle pain had less ankle dorsiflexion than the control group. This is the largest study to date using a validated measurement device as well as a control group and supports the findings of previous authors. This study supports the notion that an isolated gastrocnemius contracture may be associated with foot and ankle pain.

Declaration of Conflicting Interests

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