# EVALUATION OF CALF MUSCULAR FUNCTION DURING THE RECOVERY PHASE AFTER THE REPAIR OF AN ACHILLES TENDON RUPTURE

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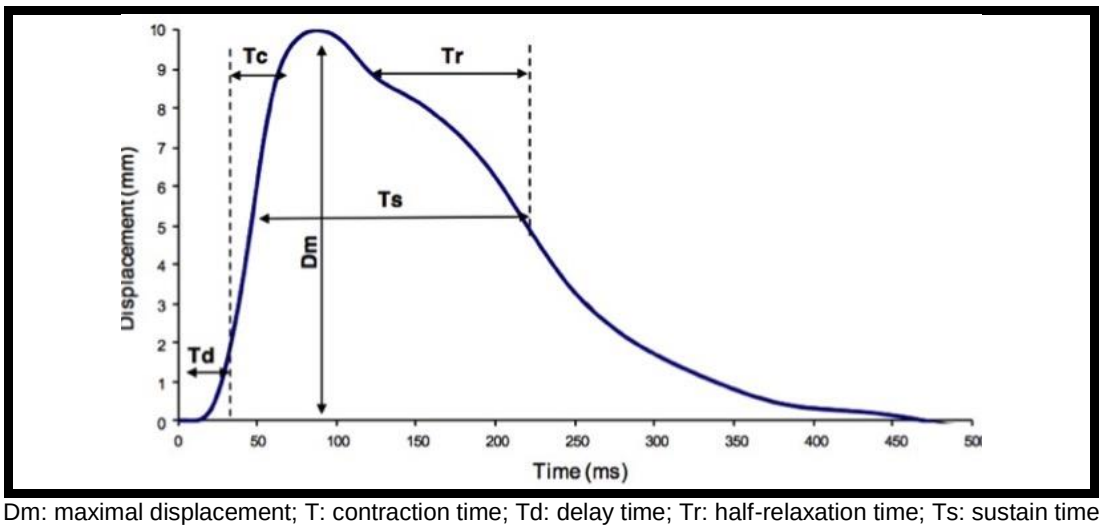
During the recovery phase after the repair of an Achilles tendon rupture, measuring calf muscular function is important for predicting prognosis. Tensiomyography (TMG) is a selective and non-invasive diagnostic method for skeletal muscular contractile properties based on the displacement of the muscle belly. TMG gives information about maximal displacement of the muscle belly (Dm), delay time, contraction time (Tc), sustain time, and relaxation time. Using TMG we evaluated a patient that had Achilles tendon rupture surgery. In this study, the Dm changed significantly compared to other parameters. The Dm decreased after cast removal day and increased gradually during the early recovery phase and then slightly decreased again during the late recovery phase. These responses of the Dm show a correlation of the recovery of muscular function.

**KEY WORDS:** Tensiomyography, Achilles tendon rupture repair.

**INTRODUCTION:** Occurrence of Achilles tendon rupture occurs in 2% of the population per year. Recently there has been increased interest in physical conditioning and joining in athletic activities in middle-aged and older patients. There are two types of Achilles tendon ruptures; direct trauma and indirect causes. Indirect causes are more frequent and result from a combination of mechanical stress and degeneration. Achilles tendon operation results are affected by several factors like age, muscle-tendon flexibility, strength, rupture site, etc. The factors that interest us most are muscle-tendon flexibility and strength of the calf muscle. TMG can evaluate the function of skeletal muscle through contraction time (Tc), maximal displacement (Dm), and other parameters. TMG was developed at the Slovenia Ljublijana Computer University. Early laboratory studies included evaluation of the reliability of short-term repetitive measurements and the reliability between operators, between days, and intra correlation coefficient (Tous-Fajardo J, 2010). Bostjan et al. (2011) found that the relatively simple method of TMG could be used to noninvasively estimate the %MHC-I (Myosin Heavy chain-I) in human vastus lateralis muscles. Recent studies of TMG are for pre-seasonal evaluation of football players' muscle condition and for evaluation of training programs (Garcia-Carcia O, 2017 & Zubac D, 2017). TMG is measured by placing two electrodes on each side of the muscle belly and a sensor directly on the muscle belly, electrically stimulating the calf, and then recording the muscular displacement (Figure 1).




Dm: maximal displacement; T: contraction time; Td: delay time; Tr: half-relaxation time; Ts: sustain time

**Figure 1: TMG parameters definition.**

The five parameters produced by TMG are:
(1) Dm: distance that is graphed by muscular contraction between the starting point and the highest point.
(2) Td: time that Dm takes to change from 0% to 10%.
(3) Tc: time that it takes to change from 0% to 90% of Dm and is related to Type I fibers of skeletal muscle.
(4) Ts: time that is taken to reach 50% of Dm.
(5) Tr: time that is taken to decrease from 90% to 50% of Dm.
This paper's purpose is to use TMG to explain calf muscular responses during recovery from Achilles tendon surgery. We evaluated the patient four times and compared the Dm of the calf muscle's GM (gastrocnemius medialis) and GL (gastrocnemius lateralis) throughout the four examinations. We are interested in using TMG with three groups. The first group is surgical and nonsurgical orthopedic patients recovering from injury. The second group is athletes evaluating and maintaining their muscular function. The third group is geriatric patient with weakened muscle especially sarcopenia.

**METHODS:** We evaluated a patient that had Achilles tendon rupture repair surgery in 2017. We explained the purpose of the study, got his informed consent, and received approval from Suncheonhyang University. The male patient was 52 years old, 163 cm, 73 kg with the operation on the left side. During the follow-up observation we did the TMG test. The first measurement was on Aug. 1, 2017 (post-operative 6 weeks, cast-removal day), the 2nd on Aug. 30, 2017 (post-operative 10 weeks), the 3rd on Sept. 26, 2017 (post-operative 14 weeks) and the 4th on Jan. 1, 2018 (post-operative 31 weeks). We measured the Dm, Td, Tc, Ts, Tr of the gastrocnemius medialis, gastrocnemius lateralis, and tibialis anterior muscles. When we measured the muscle, we put the sensor directly on the muscle belly and attached two electrodes to each side of the sensor. Then we stimulated the muscle via the electrodes and received information through the sensor.

**RESULTS:** In this study, we used TMG to record results of 5 parameters such as Dm, Td, Tc, Ts, Tr of the gastrocnemius medialis (GM), gastrocnemius lateralis (GL), and tibialis anterior muscles. We found clinically significant results of the Dm of GM and GL. The 1st date of measurement was cast-removal day and the Dm of the injured side of the GM was 0 and the Dm of the injured side of the GL was 1.08. The Dm was so low on cast-removal day that it was nearly immeasurable. That may be caused by atrophy of the calf muscle from lack of use due to the 6 weeks in a short leg cast. The Dm of the injured side increased gradually (2nd Dm of GM was 2.70, 3rd Dm of GM was 6.19 and 2nd Dm of GL was 2.02, 3rd Dm of GL was 3.76) between the 2nd and 3rd measurement dates, but the Dm of the injured side decreased (4th Dm of GM was 3.20 and 4th Dm of GL was 2.07) on the 4th date. The 2nd measurement date was 4 weeks after cast-removal day (10 weeks post-operation). Additionally, the 3rd measurement date was 8 weeks after cast-removal day (14 weeks post-operation). The 4th measurement date was 25 weeks after cast-removal day (31 weeks post-operation). The Dm of the 4th measurement slightly decreased compared to the Dm of the 3rd the measurement. We also found that the Dm of the non-injured side of the GM and GL changed. Interestingly, the Dm of the injured side of the GM changed drastically compared to the Dm of the injured side of the GL, but the Dm of the non-injured side of the GM changed gradually compared to the Dm of the non-injured side of the GL.

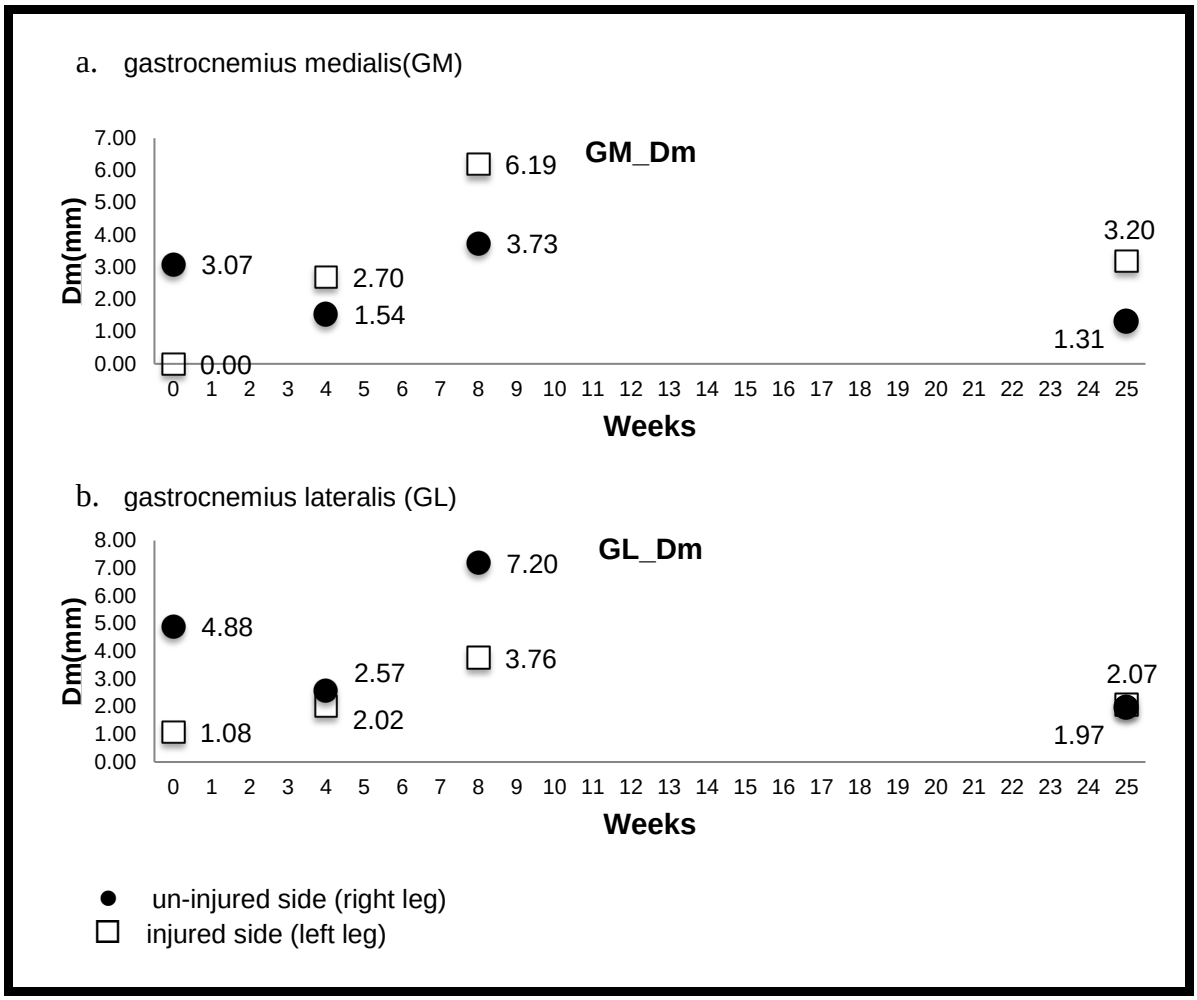



**Figure 2: Maximal displacement (Dm) of GM & GL**

**DISCUSSION:** We need a precise way of evaluating the progress and success of an Achilles tendon operation, which muscle affects the prognosis of an Achilles tendon operation, and how much the muscle function has recovered. The TMG measurement is non-invasive and can evaluate specific areas like the gastrocnemius medialis (GM) and the gastrocnemius lateralis (GL). Narici & Cerretelli (1998) provided evidence that muscle atrophy induced by disuse is associated with a decrease in muscle thickness and decrease in pennation angle.
Rado Pisot et al. (2008) found that the Dm of the vastus medialis, biceps femoris and GM significantly increased after 35 days of bed rest. They found that the Dm and Tc are reported as more important parameters than others. Decreased Dm means there is increased stiffness of the muscle or increased muscular tone. Furthermore, increased Tc means there is decreased muscular contractile force by muscular fatigue. Additionally, in the GM the change in Dm correlated with the decrease in muscle thickness. This finding suggested that people with hypertrophied muscles were subjected to more atrophy during unloading. Richard (2010) provided the average physiological cross-sectional area of GM is 21.12 $cm^2$ and GL is 9.72 $cm^2$. Alentorn-Geli (2015) evaluated the neuromuscular function and later evaluated the function of the gastrocnemius muscle. In this study, we found during the early recovery phase (from 1$^{st}$ measurement to 3$^{rd}$ measurement), that the Dm of the injured side increased gradually because the calf muscle slowly recovered from atrophy. However, the 4$^{th}$ measurement of the Dm of the injured side shows a decreased Dm compared to the 3$^{rd}$ measurement and did not go lower than the 2$^{nd}$ measurement. It means that the calf muscle of the injured side changed to a more hypertrophic state throughout the rehabilitation periods of 11 weeks. Decreased Dm means there was not only a response of muscular atrophy but also hypertrophy muscle. However, there are differential meanings of numerical value. Clinical significance of the Dm means there are changes of pattern of the Dm. Increasing Dm

means there was recovery from muscle atrophy and stiffness. The decreasing Dm means there was change to the hypertrophy muscle. Compellingly, the Dm of the injured side of the GM changed drastically compared to the Dm of the injured side of the GL.
We also found the Dm of the non-injured side of the GM and GL changed. We can presume that the non-injured sides' Dm changed according the muscular state of the injured side but we cannot explain this response for sure. If during the recovery phase pattern of Dm variation does not change according the time we have to restructure the rehabilitation program or look for other causes like operation skill, duration of cast, duration the using brace, etc.

**CONCLUSION:** The Dm was determined to be significant for measuring calf muscular function post-operationally of an Achilles tendon rupture. We can assume that these changes represent conditions from disuse atrophy to a pre-injury state. Notably, the Dm of the injured side of the GM changed drastically and the non-injured side of the GM changed gradually. We can presume that the GM is more influential than the GL on the function of Achilles tendon. This study's purpose is to use TMG to evaluate the muscle affected by an Achilles tendon repair operation. This study is also the first report on this specific topic. In the future we plan to get data from a bigger sample of patients having Achilles tendon repair operations and evaluate the effect on the calf muscle during the process of healing.

## REFERENCES

Alentorn-Geli E, Alvarez-Diaz P, Ramon S. (2015) Assessment of gastrocnemius tensiomyographic neuromuscular characteristics as risk factors for anterior cruciate ligament injury in male soccer players. *Knee Surg Sports Traumatol Arthrosc* 23:2508-13

Bostjan Simunic, Hans Degens, Jorn Rittweger, Marco Narici, Igor B. Mekjavic, and Rado Pisot. (2011) Noninvasive estimation of myosin heavy chain composition in human skeletal muscle*. Medicine & Science in Sports & Exercise.* Feb;1619-1625

García-García O, Serrano-Gómez V, Hernández-Mendo A, Morales-Sánchez V. (2017) Baseline Mechanical and Neuromuscular Profile of Knee Extensor and Flexor Muscles in Professional Soccer Players at the Start of the Pre-Season. *J Hum Kinet.* Aug 1;58:23-34.

Narici MV, Cerretelli P. (1998) Changes in human muscle architecture in disuse-atrophy evalluated by ultrasound imaging. *J Gravit Physiol* 5:73-74

Rado Pisot, Marco V. Narici, bostjan Simunic, Maarten De boer, Olivier Seynnes, Mihaela Jurdanna, Gianni Biolo, Igor B. Mekjavic (2008) Whole muscle contractile parameters and thickness loss during 35-day bed rest*. Eur J Appl Physiol*. Feb 104:409-414

Richad L. Lieber. (2010) Skeletal Muscle Structure, Function, and Plasticity.

Tous-Fajardo J, Moras G, Rodríguez-Jiménez S, Usach R, Doutres DM, Maffiuletti NA. (2010) Inter-rater reliability of muscle contractile property measurements using non-invasive tensiomyography. *J Electromyogr Kinesiol.* Aug: 20(4): 761-6.

Zubac D, Šimunič B. (2017) Skeletal Muscle Contraction Time and Tone Decrease After 8 Weeks of Plyometric Training. *J Strength Cond Res.* Jun;31(6):1610-1619.

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