# Immediate Effect of Quadriceps Elastic Taping Application as a Supplementary Treatment on Gait Performance in Patients with Knee Osteoarthritis: A Serial Case Report

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Abstract: Quadriceps strength is an important determinant of walking in subjects with knee OA (KOA). Quadriceps Elastic Taping (ET) application might immediately improve gait performance while other modalities may need time to show improvement. Case Description: Seven patients with KOA (9 knees) presented with pain during weight bearing. ET was prescribed as a supplementary treatment to improve gait performance. Increased gait performance such as walking speed and reduced excessive knee flexion during loading response was seen in 77% and 66% of subjects respectively. In order to evaluate changes in muscle contraction immediately after ET application, surface EMG examination was done and we found only 55% of subjects have increased percentage of maximum voluntary contraction (MVC). Discussion: Increased cutaneous input during ET application in the afferent nerves may activate a loop via afferent and efferent nerve fibres which eventually increasing quadriceps muscle activation that may reduce joint load during gait. Unexpectedly, increased quadriceps contraction after ET application was inconsistent, therefore placebo effect may also play an important role in developing the findings in this study. Conclusion: ET application have potential to improve gait performance in patients with KOA. Further studies are needed to prove ET effect on gait performance.

## 1 INTRODUCTION

Many functional limitations are caused by muscle impairments in knee osteoarthritis (KOA). Understanding the extent of muscle impairments, its relationship with physical function and disease progression, and the evidence behind exercise therapy that targets muscle impairments is crucial.

Muscle strength, especially quadriceps, is a major determinant of both performance-based and self-reported physical function. Quadriceps, hamstrings, and hip muscles are significantly impaired in subjects with KOA compared with age-matched controls. (Alnahdi, Zeni, and Snyder-Mackler, 2012) Quadriceps activation deficits in KOA are largely predicted due to an alteration in knee joint sensory receptors, which reduces the excitability of the alpha motoneurons via spinal and/or supraspinal mechanisms. (Rice, McNair, and Lewis, 2011)

The quadriceps control the rate of descent of the body's center of mass. Eccentric activation of these muscles also provides shock absorption to the knee. At the initial contact phase of walking, the knee flexes slightly in response to the ground reaction force. Eccentrically active quadriceps control the extent of the knee flexion. Acting as a spring, the muscle helps dampen the impact of loading on the joint. Strong muscles are less fatigable and exhibit greater motor control, thus avoiding damaging increases in shear forces and peak joint forces. (Susko and Fitzgerald, 2013)

The quadriceps femoris is a large and powerful extensor muscle, consisting of the rectus femoris and three vasti muscles, with vastus lateralis as the largest muscle with highest cross-sectional area. The two main factors that determine the muscle's force production capabilities are the muscle cross-



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sectional area and the ability of the nervous system to fully activate the muscle. (Alnahdi, Zeni, and Snyder-Mackler, 2012) Ikeda et al reported 12% reduction in quadriceps cross sectional area in women with radiographic evidence of knee OA, compared to women without radiographic evidence of knee OA. (Ikeda, Tsumura, and Torisu, 2005)

Several gait modification strategies were adopted by KOA patients to alter knee joint load, such as reduced gait speed, increased knee flexion, reduced vertical acceleration at initial contact, reduced stride length, and increased mediolateral trunk lean. (Simic, et. al, 2011) These modifications might cause increased quadriceps load and causing fatigue consequently. Quadriceps weakness increased accordingly as KOA progress.

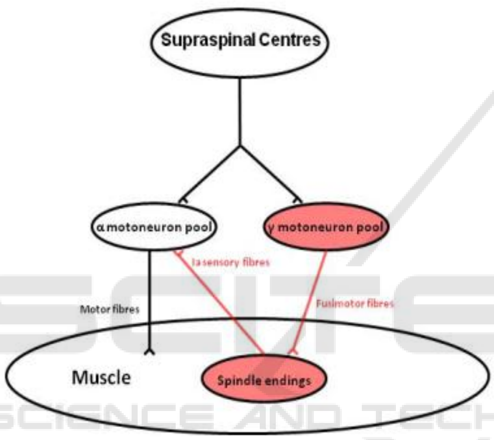


Figure 1: Muscle spindles provide a tonic excitatory input to the homonymous a-motoneuron pool via Ia sensory nerve fibres.

Taping is widely used in the field of rehabilitation as both a means of treatment and prevention of sports-related injuries. In recent years, the use of Elastic Tape (ET) has become increasingly popular. ET was designed to mimic the qualities of human skin. It has roughly the same thickness as the epidermis and can be stretched between 30% and 40% of its resting length longitudinally. (Thelen, Dauber, and Stoneman, 2008)

One of the proposed mechanisms how ET might increase muscle activation is by increased cutaneous input in the afferent nerves and therefore activating feed forward loop via afferent and efferent nerve fiber. (see Figure. 1) (Rice, McNair, and Lewis, 2011). When ET was applied on the quadriceps muscles during gait, we presumed it would improve gait alteration due to increased muscle contraction. This case series is trying to see the effect of vastus lateralis ET application on gait performance such as gait speed and knee kinematic parameter and to evaluate the muscle activation during gait in patients with KOA.

## 2 CASE DESCRIPTION

Seven females with KOA (9 knees) presented with pain during weight bearing activities. All participants age range were 49 – 69 years old and had a diagnosis of primary symptomatic knee OA according to the criteria of the American College of Rheumatology. Two patients had knee varus deformity, and none has valgus deformity. All patients did not have joint hyperlaxity. Knee pain was scored between 3 – 6 on Numeric Rating Scale (NRS). Several managements were prescribed to these patients in accordance to their problems, such as Low-Level Laser Therapy and Quadriceps strengthening. ET was prescribed as a supplementary treatment to improve gait performance.

| Subject | Gender | Age | OA Site | VAS |
|---|---|---|---|---|
| 1 | F | 69 | Unilateral | 5 |
| 2 | F | 59 | Unilateral | 4 |
| 3 | F | 55 | Unilateral | 3 |
| 4 | F | 49 | Bilateral | 5 |
| 5 | F | 52 | Unilateral | 4 |
| 6 | F | 57 | Unilateral | 3 |
| 7 | F | 50 | Bilateral | 6 |

Table 1: Subject characteristics

ET was attached using Y-strip method around vastus lateralis muscle (VL) with anchor (5 cm) attached at lateral side of patellar tendon and the tails (5 cm) were attached at lateral thigh near greater trochanter. ET was applied while patient's knee is in full flexion with 75% stretch. All participants were asked to rest for 20 minutes after application. Surface EMG electrodes were attached at VL muscle belly to measure muscle activity.

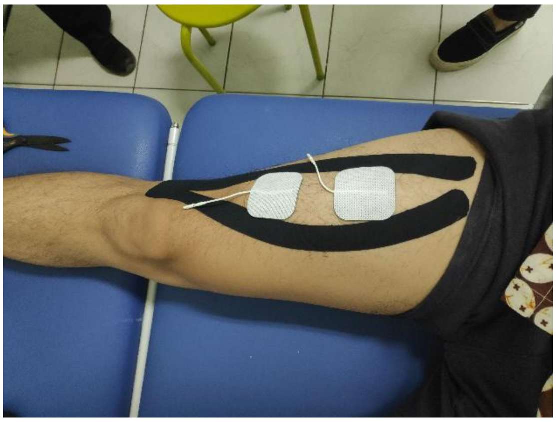

Figure 2: ET and sEMG Electrode Application.

All participants were then asked to walk at their own comfortable speed and were recorded using video recorder from anterior and lateral view. The video was then analysed using Kinovea® to measure knee kinematic changes.

Figure 3.:Gait Recorded and Analysed using Kinovea®

# 3 RESULT

Increased gait speed was observed at this case series with 6 out of 7 patients had increased speed. Average gait speed pre ET application was 0,63 m/s and average gait speed post ET application was 0,72 m/s. A systematic review was done to measure MCID in comfortable gait speed of adults with pathology and it reported gait speed MCID is 0,10 – 0,20 m/s. (Bohanon and Glenney, 2014) Reduced knee flexion during loading response was recorded in 4 out of 9 knees. The main outcome of this study is to observe changes gait performance after supplementary ET application, measured by muscle activation, knee kinematic changes, and gait speed.

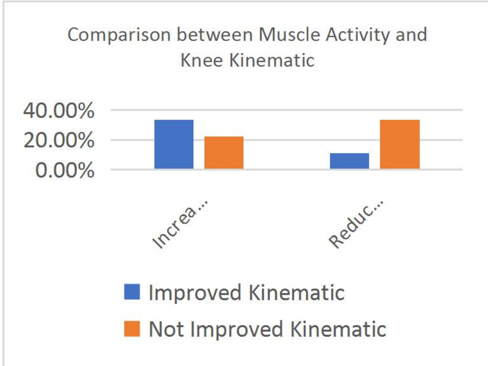


Figure 4: Comparison between Muscle Activity and Knee Kinematic

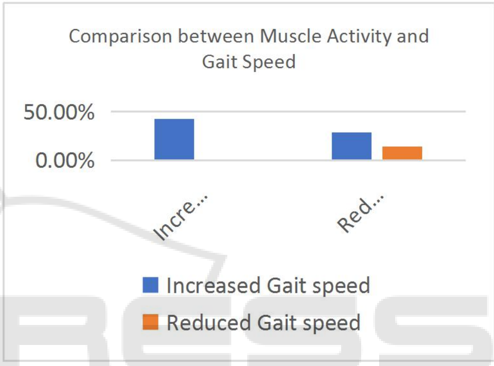


Figure 5: Comparison between Muscle Activity and Gait Speed

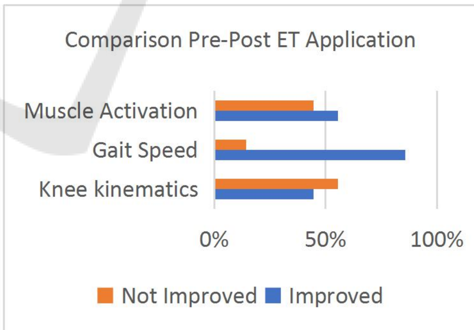


Figure 6: Comparison Pre-Post ET Application

Table 2. Knee flexion and gait speed changes

| Subject | Knee Flexion (during loading response) | | | Gait Speed (m/s) | | | Muscle Activity (% MVIC) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre ET | Post ET | Delta | Pre ET | Post ET | Delta | Pre ET | Post ET | Delta |
| 1 | 12,39 | 9,11 | -3,29 | 0,67 | 0,68 | 0,01 | 25,70% | 25,90% | 0,20% |
| 2 | 11,40 | 10,83 | -0,57 | 0,79 | 0,8 | 0,01 | 14,70% | 29,50% | 14,80% |
| 3 | 20,09 | 21,91 | 1,82 | 0,53 | 0,52 | -0,01 | 17% | 11,70% | -5,30% |
| 4 | 9,63 | 8,44 | -1,19 | 0,63 | 0,65 | 0,02 | 24,50% | 23,20% | -1,30% |
| 5 | 3,99 | 2,70 | -1,29 | 0,66 | 0,72 | 0,06 | 22,90% | 13,40% | -9,50% |
| 6 | 0,45 | 1,98 | 1,53 | 0,66 | 0,72 | 0,06 | 13,90% | 23,50% | 9,60% |
| 7 | 15,45 | 16,69 | 1,24 | 0,6 | 0,83 | 0,23 | 19,50% | 14,70% | -4,80% |
| 8 | 15,51 | 15,87 | 0,36 | 0,6 | 0,83 | 0,23 | 11,40% | 13,40% | 2,00% |
| 9 | 7,35 | 9,41 | 2,06 | 0,56 | 0,69 | 0,13 | 18,40% | 21,80% | 3,40% |
| Average | 10,70 | 10,77 | 0,07 | 0,63 | 0,72 | 0,09 | 18,67% | 19,68% | 1,01% |

Increased gait performance such as walking speed and reduced excessive knee flexion during loading response was seen in 86% and 44% of subjects respectively. In order to evaluate changes in muscle activity immediately after ET application, surface EMG electrodes was attached on VL muscle belly and we found only 55% of subjects have increased percentage of maximum voluntary contraction (MVC) (see figure 6). No adverse effect was observed during ET application.

# 4 DISCUSSION

Speed and other spatio-temporal parameters are important outcomes used to characterize gait in a wide range of pathologies. Numerous studies have been reporting slower walking speed in KOA patients compared with non-KOA individuals, and slower walking speed in severe OA compared to moderate OA patients. (Favre and Jolles, 2016). In this study, 86% of patients had an increase in their gait speed (see figure 6). This might be explained because during ET application, patients might experience decrease in knee pain, giving them the ability to walk faster. Unfortunately, we didn't record pain level pre-post ET application, since we were focusing on objective clinical improvements in gait performance. Decreased pain could be the result of increased quadriceps activity. Therefore, reducing the knee joint load.

Recent study highlighted an association between mid-stance Knee flexion moment (KFM) and OA progression, where patients walking with a larger KFM peak at baseline lost more cartilage during five-year follow-up. (Chebab, et. al, 2014). A critical review of the literature suggests that in the KOA patients the knee flexion angle (KFA) at heel strike and during early stance are greater along with reductions in the peak external knee extension moment in late stance. (Heiden Lloyd, and Ackland, 2009) This parameter is seen larger in severe compared with moderate OA patients. (Favre and Jolles, 2016) KOA patients also showed a significant smaller maximal knee extension angle in late stance. Limitation in maximal knee extension angle in late stance could be caused by contracture or pain during end range extension. Previous studies also report a lower peak knee flexion moment in early stance, which has been associated with quadriceps weakness or pain avoidance gait and could represent the intention to minimize knee joint loading. (Baert, et. al, 2013)

Reduced excessive knee flexion during loading response was seen in 44% of subjects respectively following ET application (see figure 6). We suspect that this change in knee kinematic parameter is related to the increased activation of the vasti muscles, especially the vastus lateralis. During gait, activity of the vasti musc1es begins in terminal swing (90% gait cycle (GC)). Musc1e intensity rapidly increases to a peak of 25% MMT early in loading response (5% GC). This level of effort is maintained throughout the remainder of the loading response period. They have functioned eccentrically to restrain (decelerate) knee flexion. On the onset of mid stance, the quadriceps rapidly reduces its effort and ceases by the 15% GC point. With increased quadriceps activity, we could expect reduced excessive knee flexion during loading response.

In a tonus-increasing muscle application, the elastic stretch tape exerts tension via the restoring force in the direction of origin (punctum fixum) to the fixed base, and thus displaces the skin in the same direction. This brings about support of the muscle contraction. (Kumbrink, 2014) Anatomically, muscles are described by their proximal attachments (origin), distal attachments (insertion), and actions in producing specific joint motions. After all, knowing where a muscle's proximal and distal attachments are and understanding the motion a muscle produces is essential to appreciating more complicated muscle functions. We can take this notion in another direction to better understand muscle function in a closed chain activity: If the distal segment of a muscle's attachment is stabilized, then the proximal segment is the moving end of the muscle (Houglum and Bertoti, 2012).

During loading response, quadriceps contracts eccentrically to provides shock absorption. The joint is protected from the deleterious force of full floor impact. The quadriceps react to inhibit further flexion by increased intensity of the vasti during early midstance. Further demand on the quadriceps is minimized by the tibial stability gained through the action of the soleus. This allows the femur to advance at a faster rate than the tibia (femoral on tibial movement). Therefore, quadriceps contraction during stance phase was considered as closed kinetic chain. ET application on vastus lateralis in this case series was done from lateral side of patellar tendon to lateral thigh near greater trochanter and considered as muscle facilitation, due to closed kinetic chain quadriceps activation nature during gait.

In this case series, Increased quadriceps muscle activation (% MVC) was seen only in 55% of subjects measured using sEMG. The increased muscle activity doesn't seem to be consistent on every patient experiencing improvement in gait performance (see figure 4 and figure 5). The discrepancies between increased muscle activation and improved functional performance suggesting other mechanism that might contributed to these findings including the placebo effect.

Several studies have shown mixed findings about the effect of ET application to increased muscle activation. One of the possible mechanisms of ET is placebo effect. The role of expectation in the placebo effect was demonstrated in a series of clinical trials investigating the treatment of postpartum pain. While the majority of the literature on the biological approach relates the placebo effect to the release of endogenous opioids and dopamine as an explanatory mechanism. Dopamine may also play a significant role in controlling opioid release and could therefore play a role in the transmission and perception of pain. (Thelen, Dauber, and Stoneman, 2008)

# 5 LIMITATION

This case series is a retrospective study with limited number of cases. Bigger study with randomized prospective design and several ET application methods (including different direction and stretch) is needed to evaluate the effect of ET on increased muscle activation and strength, as well as improvement on gait performance.

# 6 CONCLUSION

Quadriceps ET application have the potential to improve gait performance immediately in patients with KOA. Better studies are needed in order to evaluate whether these changes were associated to ET application.

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