Localized Short Elastic Tape Affects the Hamstring Reflex on Anterior Cruciate Ligament Deficient Knee

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**ABSTRACT**

We evaluated the effect of localized continuous cutaneous stimulation on functional stability of the knee in a subject with an old anterior cruciate ligament (ACL) complete tear. Three controlled comparative experiments were performed: 1) without applying the cutaneous stimulation to deficient and uninjured knees, 2) with applying the stimulation to deficient knee, and 3) with applying the stimulation to deficient knee with subcutaneous anesthesia. For the cutaneous stimulation, we applied a short elastic tape (SET) on the lateral side of the knee, which did not immobilize the joint. We evaluated functional stability of the knee by measuring response latency of the stretch reflex in the hamstring muscle after acute anterior translation of the tibia. The latencies in ACL deficient and uninjured knees without applying SET were 66.7 ms and 43.4 ms, respectively. When SET was applied, the value in the deficient knee was shortened to 49.0 ms, and the value was prolonged to 58.5 ms after subcutaneous anesthesia. Our data indicate the possibility that continuous cutaneous stimulation to a small and localized area in ACL-deficient knee may improve the stretch reflex, which may contribute to the functional stability of the knee.

**Key Words**: ACL deficient knee, short elastic tape (SET), hamstring muscle, stretch reflex

**Introduction**

It is common knowledge that the primary role of ligaments is to provide mechanical stability for joints. In addition, the presence of mechanosensitive receptors in ligaments and their attachment sites (KENNEDY et al., 1982; ZIMNY, 1988) have suggested that the ligaments also contribute to functional joint stability. A research group of Johansson et al. (JOHANSSON et al., 1991; SJÖLANDER et al., 2002) had revealed the relationships between the mechanosensitive receptors in ligaments of knee and stretch reflexes in the muscles surrounding the knee, using animal preparations. Moreover, on
patients with anterior cruciate ligament (ACL)-deficient knees, Beard et al. (1993) reported the prolongation of mean response latency of the stretch reflex in the hamstring muscles. Those results suggest that the afferent information from mechanosensitive receptors in ACL contribute to control of the stretch reflex, supporting that the ACL contributes to functional stability of the knee.

In other words, the functional stability is decreased in ACL-deficient knee. Recent studies revealed that the prolonged latency of the stretch reflex in such patients was shortened by wearing a functional brace on the deficient knee (LAM et al., 2002; WOJTYS et al., 1996). The studies indicate that those methods in the ACL-deficient knee improve not only mechanical stability but also functional stability. However, these studies have problems for examining the relationship between ACL and functional stability of the knee or for developing a method for improving functional stability of the knee. The first problem in many studies is that all subjects underwent surgical invasion, including arthroscopy or ACL reconstruction (BEARD et al., 1993; JENNINGS et al., 1994; LAM et al., 2002; WOJTYS et al., 1996). It has been pointed out that such invasion might affect the experimental results significantly (JENNINGS et al., 1994; SJÖLANDER et al., 2002). The second problem is that the subjects had a variety of grades of ACL injury. Such subjects might not be uniform in the grade of functional stabilities of the knee. Another problem is that it was impossible to distinguish functional and mechanical stability improvements because both effects might have come about simultaneously especially in studies that applied a bracing method or conventional taping method.

In present study, to overcome the problems mentioned above, we selected a subject with an old, complete ACL tear who had rejected invasive arthroscopy and ACL reconstruction for personal reasons. We firstly examined the response latency of the stretch reflex in the hamstring muscle caused by acute anterior translation of the tibia. Based on these results, we investigated whether the latency was affected by stimulating a small, localized cutaneous area. For the cutaneous stimulation, we applied a short elastic tape (SET), which did not provide mechanical joint stability, on lateral side of the knee.

MATERIALS AND METHODS

**Subject**

The subject was a 24-year-old male who had injured his right knee joint while practicing judo seven years ago, but did not receive any treatment for personal reasons. The Magnetic resonance imaging (MRI; T1-weighted, Fig. 1) revealed a complete ACL tear in the right knee joint. With the exception of this deficiency, he had no history of any other serious injury to the right lower extremity. We used the right knee as an ACL-deficient one and the healthy left knee as a control. The study was approved by the local ethics committee and adhered to the Helsinki Declaration. The subject gave informed consent.

![Fig. 1 MRI (T1-weighted) of the right knee of the subject, revealing a complete ACL tear](image)

**Method for acute anterior translation of the tibia**

The subject lay down on a bed in a supine position with his knees bent at an angle of 90 degrees. The sole of his foot was firmly fixed on the bed with the second metatarsal pointing forward.

Acute anterior translation of the tibia was performed 15 times in the following way. In order to generate impact, we made a device that dropped a 2 kg plumb bob 50 cm using a pulley (Fig. 2). From this impact, acute anterior translation of the tibia occurred at the proximal portion of the tibia and not at the insertion of the hamstring muscle. To prevent the subject from predicting the interval between each impact, he was asked to wear a
blindfold and earplugs during the experiment. In addition, he put on a set of headphones and listened to white noise.

Electromyogram (EMG) measurements

An acceleration transducer (TA-AR2G, TEAC Co., Tokyo, Japan) was used to detect the starting point of the acute anterior translation of the tibia, and an electromyograph (MyoSystem1200, Noraxon USA Inc., AZ, USA) with surface electrodes was used to detect the starting point of the hamstring muscle contraction. The interval of these points was regarded as the response latency. The acceleration transducer was placed on the tibial tuberosity and the surface electrodes for EMG were placed on the belly of the hamstring muscle. Signals from the transducer were passed through an amplifier and recorded synchronously with EMG data by a data recorder. This experimental schema is illustrated in Fig. 2.

Experimental patterns

This study consisted of the following three experiments:

1. No SET was applied. The latencies of both the deficient and uninjured knee were measured.
2. SET was applied. The latencies of the deficient knee only were measured.

To apply SET stimulation, a 7.5 cm × 7.5 cm adhesive elastic tape (EB-75, Nitto Denko Co., Tokyo, Japan) was stretched to its maximum size (approximate 7 cm × 10 cm) and applied to the lateral joint space in the knee as shown in Fig. 2. To make the area of cutaneous stimulation as small as possible, and to get an adequate stimulation effect sufficiently, we chose an application size. Commercial functional knee braces have lateral and medial condyle pads. The size of our SET was based on the sizes of the lateral condyle pads of functional knee braces.

3. An anesthetic (40 ml of 0.5% lidocaine) was subcutaneously injected to the wide area around the lateral joint space in the knee. The area included the localized area of SET application in the experimental pattern 2. After confirmation of the loss of cutaneous sensation, SET was applied to the center of the anesthetized area. The latencies of the deficient knee only were measured.

Data analysis

The data obtained was downloaded onto a personal computer through an AD converter (PowerLab/8s, ADInstruments, CO, USA), and 15 EMG data for each experimental pattern were averaged using data analysis software (Scope 3.6.8., ADInstruments, CO, USA). The latencies were obtained from the averaged EMG data. The results were evaluated by comparing the latency of each experimental pattern.

Results

As shown in Table 1, the time between the starting points for acute anterior translation of the knee

<table>
<thead>
<tr>
<th>Pattern 1</th>
<th>Pattern 2</th>
<th>Pattern 3</th>
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<tr>
<td>deficient knee</td>
<td>66.7 ms</td>
<td>49.0 ms</td>
</tr>
<tr>
<td>uninjured knee</td>
<td>43.4 ms</td>
<td>–</td>
</tr>
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motoneuron pools by nociceptive afferents (JENNINGS et al., 1994; SJÖLÄNDER et al., 2002). Therefore, it has been speculated that the excitability of the muscle spindles in the ACL-deficient knee might be different from that in uninjured knees (SJÖLÄNDER et al., 2002). Therefore, it has been suggested that the difference of the excitability might cause a difference in response latencies of the stretch reflex which contributes to functional stability of the knee (SJÖLÄNDER et al., 2002). Beard et al. (1993) demonstrated that the mean latency of the stretch reflex in the hamstring muscles caused by acute anterior translation of the tibia was significantly longer in ACL-deficient knees as compared to that in uninjured knees.

However, it was pointed out that nociceptive stimulus caused by arthroscopy had probably remained in each patient in their experiment because they carried out the experiment at three weeks after the arthroscopy (JENNINGS et al., 1994). Such nociceptive stimulus has the potential to suppress the excitability of the motoneuron pools by nociceptive afferents (JENNINGS et al., 1994; SJÖLÄNDER et al., 2002). Therefore, in experiments on patients who underwent surgical invasion including arthroscopy or ACL reconstruction, the remained nociceptive stimulus might affect the experiment results significantly. In addition to the problem, in many studies investigating the involvement of the ACL in the functional stability of the knee, the subjects had a variety of grades of ACL injury. Such subjects might not be uniform in the grade of functional stabilities of the knee. Hence, a study investigating the functional stability of the knee should be performed on subjects who have not undergone surgical invasion such as arthroscopy or ACL reconstruction, and on subjects with complete ACL tears in which afferent information from mechanosensitive receptors in the ligament is of no use to the muscle spindle system.

To overcome these problems, we selected a subject with an old, complete ACL tear in present study. As mentioned in the methods section, our subject injured his right knee seven years prior to the study, and he did not receive any invasive stimulus, such as arthroscopy or reconstructive surgery. We only studied on one subject because it was very difficult to find other subjects who met our experimental requirements. We found that the response latencies in the ACL-deficient and uninjured knee were 66.7 ms and 43.4 ms, respectively. Obviously, the latency in the ACL-deficient knee was longer than that in the uninjured knee. It indicates that the gain of stretch reflex in the hamstring muscle have decreased in the ACL-deficient knee, suggesting the decrease of functional joint stability in the ACL-deficient knee.

To improve functional stability in the ACL-deficient knee, we studied whether cutaneous stimulation around a joint could increase the gain of the reflex. Johansson et al. (1989b) showed that natural stimulation of skin afferents increased the firing rate of the spindle afferents. It suggested that afferent information from mechanosensitive receptors in skin might affect the spindle afferents via motoneurons. In our experiment, it was shown that applying SET to the lateral side of an ACL-deficient knee shortened the latency of the stretch reflex in the hamstring muscle. Additionally, it was shown that subcutaneous anesthetization wiped out the effect of SET. These findings have indicated that weak continuous stimulation might increase the gain of the stretch reflex. As for the putative mechanism for increasing the gain, it is suggested that SET increases input to cutaneous afferents, and may increase the excitability of muscle spindles in the hamstring muscle via motoneurons.
Obviously, the main purpose of a bracing method or a conventional taping method for the joint with ligament deficiency is to provide mechanical stability. Recently, a few research groups have pointed out that those methods not only stabilize the joint mechanically, but also improve proprioceptive joint function (LAM et al., 2002; WOJTYŚ et al., 1996); i.e., those methods also improve functional joint stability. They showed that wearing a functional knee brace on ACL-deficient knees shortened the mean latency of the stretch reflex in hamstring muscles (LAM et al., 2002; WOJTYŚ et al., 1996). Those findings suggest that cutaneous stimulation by wearing a brace may increase the gain of hamstring reflex and supports our findings. However, the possibility of stabilizing a knee mechanically by wearing a brace can not be ruled out. Additionally, a brace stimulates a wide cutaneous area around the knee joint. Our SET method differs from bracing and conventional taping methods by stimulating a small, localized cutaneous area of the knee and not stabilizing the knee joint mechanically. Therefore, the SET method may improve only functional joint stability. Additionally, our finding supports the hypothesis that bracing or conventional taping methods may also contribute to the functional stability of the joint.

References


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