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Case Report

Does the Surgical Technique Applied Influence Muscle Activation after ACL Reconstruction?

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Abstract

Background: Non-contact injuries of the anterior cruciate ligament (ACL) are serious problems in recreational, amateur, and professional sports. Simultaneous ACL reconstruction with lateral extra-articular tenodesis (LET) according to Lemaire intends to reduce rotational knee instabilities with unknown consequences for the neuromuscular system. The main goal of this report was to identify and compare voluntary and involuntary muscle properties of the knee extensor apparatus in matched high-performance team-sport athletes after ACL injury and reconstruction surgery with and without an additional LET.

Case Report: The participant examined was a 26-year-old male professional team-sport athlete who experienced a non-contact ACL injury. Voluntary and involuntary muscle activation characteristics of the vastus lateralis were examined nine months after ACL reconstruction using a hamstring tendon autograft and an additional LET. At the injured side, the muscle fiber conduction velocity values were between 73 and 85 percent of the uninjured side. The maximum voluntary contraction resulted in a markedly lower post-tetanic twitch torque at the injured side.

Conclusion: The results of this case presentation suggest that the extent of the surgical intervention may alter different knee muscle activation characteristics.

Keywords: Lemaire; Professional Athlete; Return To Sport; Electrical Stimulation; Surface EMG

Introduction

Non-contact injuries of the anterior cruciate ligament (ACL) are serious problems in recreational, amateur, and professional sports. Despite improved surgical and rehabilitation methods, ACL injury rates remain unacceptably high [1]. Rotational knee instabilities associated with ACL tears cannot always be fixed using isolated reconstruction of the ACL. Simultaneous ACL reconstruction with lateral extra-articular tenodesis (LET) according to Lemaire was initially addressed in patients with reinjury, extreme hyperlaxity or grade III pivot shift results [2]. Despite controversial opinions, the indication was later extended to competitive pivoting sports [3]. However, enhanced mechanical stability may be at the cost of altered neuromuscular control since ligament mechanoreceptors play an important role in muscle coordination and reflex regulation of joint stability [4]. Thus, our main goal was to identify voluntary and involuntary muscle properties of the knee extensor apparatus in a high-performance athlete after ACL injury and reconstruction surgery with LET. Also, we aimed at comparing the results to findings for a matched athlete without additional surgical stabilization.

Case Report

The participant examined was a 26-year-old male (mass 77 kg, height 178 cm) professional team-sport athlete who experienced a non-contact ACL rupture at the non-dominant side. Surgical

reconstruction was performed using a quadrupled hamstring tendon autograft [5] and an additional LET (+LET) [6]. The assessments were performed at the time the athlete was approved for sport-specific training content by the treating physician at nine months after surgical intervention. For comparison purposes, data from a matched team-sport athlete without LET (–LET) was selected from the database of our laboratory. The protocol of the measurements was approved by the Institutional Review Board and conformed to the Helsinki declaration. Knee extensor contractions were performed seated on a custom chair with hip and knee joints at 90 degrees of flexion for five seconds at both sides [7]. Neuromuscular assessments comprised vastus lateralis muscle activity (root mean square, RMS and muscle fiber conduction velocity, CV) during maximal (MVC) and submaximal (20%, 40%, 60% and 80% MVC) voluntary isometric contractions as well as muscle twitch contractions before and after the 6-s MVC. Mechanical and electromyographical data were recorded in monopolar mode (ELSCH004, Spes Medica, Genoa, Italy) using the EMG-USB2+ system (OT Bioelettronica, Turin, Italy). Muscle twitches were elicited with indirect percutaneous stimulations of the femoral nerve using a muscle stimulator (Digitimer DS7A, Letchworth Garden City, UK). Single rectangular electrical stimuli of 400V and 1ms duration were applied to evoke resting (RTT) or potentiated (PTT) twitch torques before and after MVC, respectively. The maximum force was converted to torque and related to body mass. A force over amplitude (RMS) ratio was calculated for the MVC trial indicating neuromuscular efficiency [8]. The PTT was expressed as a percentage of the RTT.

Results

Neither athlete showed rotational knee instability at the time of the neuromuscular assessments. Normalized quadriceps extensor torque values were between 3.61 and 4.05 Nm/kg. Both athletes achieved symmetrical extensor strength values (+LET: 92%, –LET: 107%). Neuromuscular efficiency was comparable between sides, with less force per unit of muscle activation in +LET (injured: 0.87 Nm/µV, uninjured: 0.82 Nm/µV) as compared with –LET (injured: 2.00 Nm/µV, uninjured: 2.35 Nm/µV).

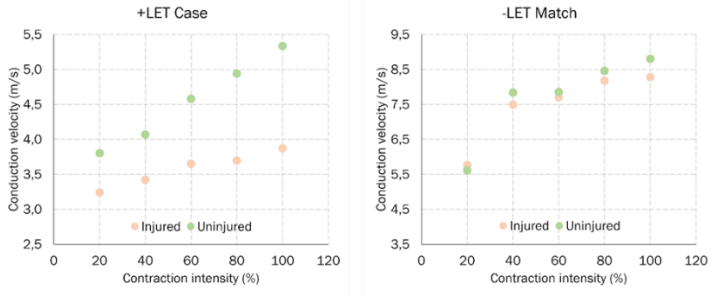

Figure 1: Side comparisons of vastus lateralis muscle fiber conduction velocity at different contraction intensities. Note the different scale on the y-axes.

The CV increased with increasing contraction intensity (Figure 1). At the injured side, the +LET achieved CV values of between 73 and 85 percent of the uninjured side, with higher deviations at higher contraction intensities. The MVC task led to a post-tetanic potentiation with markedly lower PTT values in +LET as compared with –LET (Figure 2).

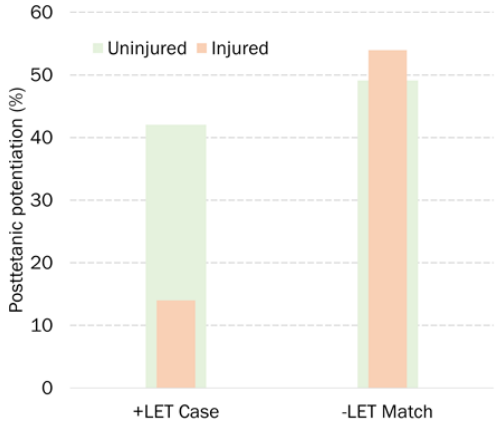

Figure 2: Posttetanic potentiation after the maximal voluntary isometric contraction as a percentage of the resting twitch torque.

Discussion

Voluntary and involuntary muscle properties were examined and contrasted in two athletes after ACL injury and reconstruction with and without additional LET and rehabilitation. Although both exhibited sufficient knee extensor strength values, vastus lateralis muscle activation and activity-dependent potentiation showed considerable limitations in the +LET case only. In the +LET case, the amount of force produced per unit of muscle activation was more than 50% lower than in the –LET but comparable at both sides. The lower muscle fiber CV indicates a lower muscle fiber diameter and thus a lower proportion of type II muscle fibres in +LET in general. The marked restriction of the muscle fiber CV at the injured side in +LET can be explained by a local type II fiber atrophy which is known to occur after joint injuries [9,10]. Further, the inability to fully activate a muscle may be associated with arthrogenic muscle inhibition [11] or a consequence of increased lateral tibiofemoral contact pressures due to the Lemaire procedure [12]. Moreover, the surgery-related differentiation may additionally lead to persistent neurological impairments, which also limit effective rehabilitation [13]. The activity-dependent potentiation (e.g., potentiated twitch torque) is particularly related to type II muscle fibers [14]. In both, the +LET and –LET cases, the post tetanic potentiation was below the average (70.6%) of uninjured men [15]. This can be explained either by the shorter duration of the conditioning activity (6 vs. 10s) or by the ACL injury experienced.

This methodology is not free of limitations. The electrically evoked torques are results of a single observation [16]. Averaged responses enhance the sensitivity of the technique [17]. Their variability needs to be explored in future studies.

Conclusion

The results of this case presentation suggest that the extent of the surgical intervention may alter different knee muscle activation characteristics. In the +LET case, the lower post-tetanic potentiation may potentially result from a reduced myosin light chain kinase activity or be due to a differentiation after the surgical intervention.

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