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Original research

Comparison of knee flexion isokinetic deficits between seated and prone positions after ACL reconstruction with hamstrings graft: Implications for rehabilitation and return to sports decisions

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ABSTRACT

Objectives: Hamstrings grafts are commonly used in ACL reconstruction, however, the effect of graft harvesting on knee flexion strength has not been longitudinally evaluated in functional positions. We hypothesized that greater deficits in knee flexion strength exist in the prone compared to the seated position and these deficits remain as rehabilitation progresses.
Design: Case series.
Methods: Forty-two consecutive patients who underwent ACL reconstruction with a hamstrings graft were followed prospectively for 9 months. Isokinetic knee flexion strength at a slow and a fast speed were collected at 3, 4, 6, and 9 months in two different positions: conventional (seated) and functional (0° of hip flexion).
Results: Peak torque knee flexion deficits were higher in the prone position compared to the seated position by an average of 6.5% at 60°/s and 9.1% at 180°/s ($p < 0.001$).
Conclusions: Measuring knee flexion strength in prone demonstrates higher deficits than in the conventional seated position. Most athletes would not be cleared to return to sports even at 9 months after surgery with this method.

1. Introduction

Anterior cruciate ligament (ACL) tear is a common sports injury that is frequently treated surgically, particularly in the young athlete. The most common graft currently used for ACL reconstruction (ACLR) is the hamstrings autograft.[1] The natural history of hamstrings graft harvesting has been the topic of several investigations as there is concern about knee flexion strength deficits. It has been widely accepted that the hamstrings of most patients regenerate after harvesting for ACLR; recent research suggests that regeneration is evident in 77%[2] to 90% of knees.[3,4] It has recently been suggested that the regenerated hamstrings tendons appear to have similar structure as the tendons in the non-harvested side.[2] Most studies that have investigated knee flexion strength recovery after ACLR with a hamstrings graft on isokinetic devices (typically in a seated position) found that there are no residual strength deficits[5–8] even though patients frequently describe perceived weakness. To explain this paradox, recent research has suggested that knee flexion strength should be measured in deep knee flexion angles where the deficits are more obvious.[4,9,10]

However, in most sports that involve cutting and landing the athlete rarely needs to perform activities from deep knee flexion angles. Instead, in most situations the athlete needs to function from a position where both the knee and the hip are close to neutral position. Therefore, even when strength deficits exist in deep knee flexion angles their functional importance for most athletes is questionable. An alternative explanation may be that in the seated position where most studies have placed patients during isokinetic evaluations the hip is in too much flexion to replicate

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common functional athletic activities. Isokinetic testing with the hip in neutral flexion/extension would more accurately replicate the position that the hamstrings need to function during sports and subsequently provide more clinically relevant information on knee flexion strength.

Although some studies[4,9,10] measured isokinetic knee flexion strength in both prone and seated positions, they did not directly compare the deficits between the two positions. Additionally, they measured knee flexion strength at one time point after surgery and, thus, they did not provide any information on the longitudinal changes in knee flexion strength. Elmlinger et al[9] suggested that future research should investigate knee flexor strength changes from the prone position over the course of rehabilitation.

Therefore, a longitudinal study of isokinetic knee flexion strength in patients after ACLR with a hamstrings graft is needed to identify if deficits are more prevalent in the prone position and how they evolve over the course of rehabilitation. We hypothesized that greater deficits in knee flexion strength exist in the prone compared to the seated position and these deficits remain as rehabilitation progresses.

2. Methods

Patients who were referred to a large outpatient physical therapy clinic and met the following inclusion criteria were enrolled in the study: (a) ACL reconstruction with a quadruple hamstrings autograft, (b) no associated ligamentous injuries or meniscal tear in more than 25% of either meniscus, (c) no associated cartilage restoration or meniscal repair procedures, (d) no history of knee injury or pathology in the contralateral knee, (e) less than 5 mm side to side difference in the instrumented Lachman test (at 3, 4, 6, and 9 months), (f) no serious post-surgical complications such as infection or fracture, (g) available isokinetic data testing at 3, 4, 6 and 9 months and (h) no history of neuromuscular or systemic disease. The surgical details were extracted from the surgeon's report before patients were offered participation in the study. Forty-two patients (39 men and 3 women) met the inclusion criteria. The average age was 24.6(7) years old, weight was 79.4(12) kg and height was 178.9(6) cm.

After completing an informed consent form that was approved by the local ethics committee, the participants were enrolled in a standardized rehabilitation protocol. All subjects underwent a standard ACLR with a quadruple (semitendinosus-gracilis) hamstrings graft. The reconstructions were performed by 12 different sports medicine surgeons who each had a minimum of 5 year experience with the surgical technique. Graft fixation was achieved by cross pins in 27 patients and endobutton in 15 patients. A single bundle technique was used in 41 patients while one patient had a double bundle reconstruction. A transtibial tunnel drilling technique was used in 28 patients and a medial portal technique in 14 patients. The structured rehabilitation protocol was based on the principles of the accelerated rehabilitation protocol that has been described elsewhere[11] and modified for hamstrings grafts by delaying knee flexion strengthening exercises. The protocol emphasized swelling reduction, early return of range of motion, patella mobility, early weight bearing, strength training and proprioception exercises. All interventions were performed by the same physical therapist while a second physical therapist performed all testing and data collection.

Isokinetic testing was performed on the Cybex Norm 770 (Medway, MA) at 3, 4, 6 and 9 months after the ACLR as per the procedures that have been described elsewhere.[12] Briefly, prior to the isokinetic test, subjects warmed up by riding a stationary bike for 5 min at 90 rpm in a submaximal effort. For the seated position, placement of subjects was standardized by placing their hip

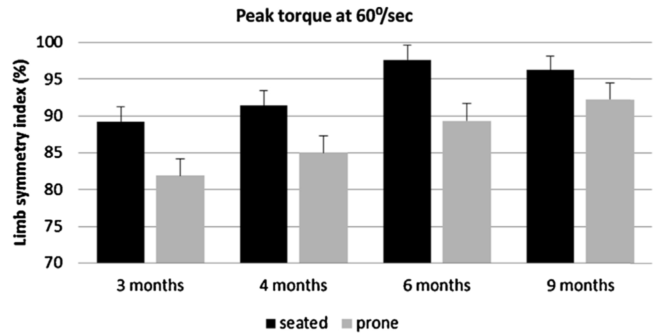

Fig. 1. Peak torque at 60°/s for knee flexion at 3, 4, 6, and 9 months from the seated and prone positions. The deficits were statistically higher in the prone position.

at 90°, their trunk and upper thigh was stabilized by belts, and the distal end of the moving arm was attached immediately superior to the lateral malleolus. The axis of the dynamometer was aligned with the axis of the knee and allowed a range of motion from 0° to 105° of flexion. For the prone position, all parameters were the same as in the seated position but patients were placed prone with their trunk supported and the hip at 0° of flexion/extension as per manufacturer's recommendations. The testing position was randomized between subjects. Gravity correction was applied to allow for accurate comparisons. The protocol included three submaximal extension/flexion concentric trials followed by three maximal trials with the dynamometer set at 60°/s. After a 30 s break, three submaximal and three maximal trials at 180°/s were performed. The peak torque for knee flexion in each angular velocity (average of three trials) was calculated. Knee flexion peak torque measurements in patients with ACLR have excellent reliability (intraclass correlation coefficients ≥0.90).[9] We measured both legs at each time as it has been previously demonstrated that isokinetic performance of the healthy leg changes during the course of the rehabilitation protocol after knee surgery.[12]

A repeated measures MANOVA was performed with time (3, 4, 6, and 9 months) and position (seated, prone) as the independent variables and the two different isokinetic speeds (60 and 180°/s) as the dependent variables. The α level was set *a priori* at 0.05. Univariate ANOVA post hoc and pairwise tests were performed in the presence of a statistically significant MANOVA to identify the conditions that were statistically significant. The Mauchly's test of sphericity was used to test for equality of variances.

The average of three trials was calculated for each speed and condition. A limb symmetry index was calculated as per the formula: peak torque from involved leg/peak torque from uninvolved leg × 100%. With this method, each value is presented as a proportional deficit (percentage) of the operated compared to the non-operated leg.[13]

3. Results

The sphericity assumption was not violated for any comparison ($p \geq 0.144$). The MANOVA revealed main effects for position ($p < 0.001$) and time ($p = 0.007$) but not for their interaction ($p = 0.869$). Post hoc tests revealed that peak torque knee flexion deficits were higher in the prone position compared to the seated position by an average (across all time points) of 6.5% at 60°/s and 9.1% at 180°/s (Figs. 1 and 2). The deficits at the 9-month follow-up were higher by 4% at 60°/s and 9% at 180°/s in the prone position.

Regarding the effect of time at 60°/s, there was an improvement from the two earlier tests (3 and 4 months) to the two later tests (6 and 9 months) ($p \leq 0.005$). At 180°/s, there was an improvement between the 3 month test and the 9 month test ($p = 0.013$) and