EFFECT OF HAMSTRING TENDON AUTOGRAFT FOR ACL RECONSTRUCTION ON KNEE EXTENSION/FLEXION STRENGTH DEFICITS AND KNEE FUNCTION

Jennifer M Manning[1], Julie R Steele[2], Amanda J Clingeleffer[1], and Leo A Pinczewski[1]
[1]Australian Institute of Musculo-skeletal Research, Sydney, Australia
[2]University of Wollongong, Wollongong, Australia

INTRODUCTION

The anterior cruciate ligament (ACL) is an intra-articular ligament of the knee (Engle, 1991) whose primary function is to limit anterior tibial translation relative to the femur (Moore, 1992). Rupture of the ACL is a debilitating condition which can result in episodes of instability, pain and swelling, particularly during activities involving sidestepping and pivoting. Therefore, ACL reconstruction is advised following ligament rupture so athletes can return to an active and competitive lifestyle without experiencing episodes of instability (Moyer et al., 1986).

One current technique used to reconstruct the ACL involves harvesting the hamstring (H) tendons (semitendinosus and gracilis*) which are then doubled to produce a four strand graft. The graft is then inserted into the origin and insertion sites of the native ACL (Smith and Nephew Donjoy Inc., 1995). Following this reconstructive procedure the knee joint is clinically stable. However, the surrounding musculature is thought to be compromised due to lack of activity during recovery and due to the effects of surgical procedure (Aglietti et al., 1994). As both the quadriceps (Q) and H play an important role in knee functioning, regaining full strength of the two muscle groups is imperative for athletes to successfully return to full activity. Yasuda et al. (1995) reported that harvesting the H tendons did not affect Q strength, however, H strength was significantly lower until nine months post-surgery. The authors concluded that the H strength loss was minimal and considered harvesting the H tendons minimized donor site morbidity. However, the authors failed to examine the relationship between knee extension/flexion strength and subjective ratings of knee function. It was therefore the purpose of this study to determine knee extension/flexion strength deficits following H tendon harvesting for use in ACL reconstruction

*Although gracilis is not anatomically classified as a hamstring muscle, the reconstruction technique using the semitendinosus and gracilis tendons is traditionally called a "hamstring tendon reconstruction" (Brown et al., 1993). Therefore, gracilis was classified as a hamstring muscle in this study.

and to determine if there was any relationship between lower limb strength deficits and subjective ratings of knee function.

METHODS

Thirty unilateral, isolated subacute ACL deficient athletes (mean age = 24.7 ± 4.9 years) who were patients of the North Sydney Orthopaedic and Sports Medicine Centre were randomly assigned to an experimental group (n = 15) and a control group (n = 15). The experimental subjects had the H tendons harvested from their ACL uninjured limb. Therefore, they had one limb that underwent ACL reconstruction and one limb that underwent H tendon harvest. The control subjects had the H tendons harvested from their ACL injured limb. Therefore, they had one limb that underwent ACL reconstruction combined with H tendon harvest and one limb that did not undergo any treatment.

Following a standard warm up, the protocol of Kannus et al.(1987) and a Cybex ® 11+ isokinetic dynamometer was used to assess the isokinetic and isometric strength of the Q and H. This procedure was completed on both limbs at pre-surgery and at 3 and 6 months post-surgery. Strength deficits were calculated (i.e., uninjured limb minus injured limb) using the Strength Scoring Scale of Kannus et al. (1987).

Subjective ratings of knee function were collected on the injured knee using the Subjective Assessment component of the International Knee Documentation Committee (IKDC) form at the same three testing sessions. The IKDC form is used to evaluate subjective ratings of knee function, activity level and symptoms of pain, swelling and partial and full giving way.

A two-way repeated measures ANOVA design with one between factor (subject group: experimental versus control) and one within factor (test session: pre-surgery and 3 and 6 months post-surgery) was used to determine if harvesting the H tendons significantly ($p \leq 0.05$) affected knee extension1 flexion strength. This was completed on the score for the Q and H as well as the total strength score (addition of Q and H scores).

The overall grade from the IKDC form was converted into ranked data. A Kruskal-Wallis one way ANOVA on ranks was completed to determine whether harvesting the H tendons significantly ($p \leq 0.05$) affected the subjective rating of knee function. A Spearman Rank Order Correlation was then conducted to correlate subjective ratings of knee function and knee extension/flexion strength deficits.

RESULTS AND DISCUSSION

The means and standard deviations for the Q, H and total strength scores for the experimental and control subjects are presented in Tablel.

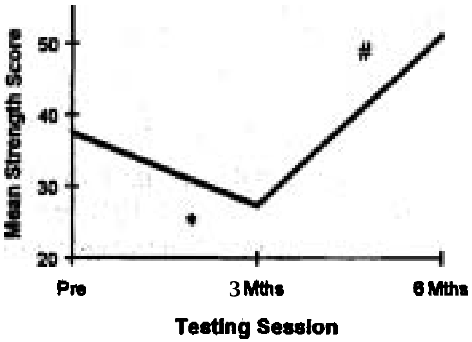
Table 1.
Knee strength scores for the experimental andcontrol subjects at pre-surgery and at 3 and 6 months post-surgery.

	Experimental				Control		
	Test Week	n	Mean	±SD	n	Mean	±SD
Quadriceps	Pre	15	26.7	9.8	15	17.4	9.7
	3 Months	15	18.2	8.7	15	13.3	14.2
	6 Months	14	30.1	8.71	4	27.1	11.3
Hamstring	Pre	15	19.8	15.4	15	15.5	10.4
	3 Months	15	18.3	8.8	15	5.6	6.9
	6 Months	14	24.1	7.4	14	18.9	9.3
Total	Pre	15	43.7	17.3	15	32.1	18.8
	3 Months	15	33.3	15.6	15	22.5	19.5
	6 Months	14	54.1	13.1	14	45.9	18.3

When the Q strength scores were analyzed, there was no significant main effect of subject group ($F_{1,49} = 2.362$, p = 0.131) or testing session ($F_{2,49} = 0.804$, p = 0.453) and no significant subject group x testing session interaction ($F_{2,49} = 0.0503$, p = 0.951). Therefore, harvesting the H tendons did not significantly affect the strength of the Q muscles.

When the H strength scores were analyzed, there was a significant main effect of testing session ($F_{2,42} = 4.822$, $p = 0.013$) when the data were pooled across subject groups. Although lower strength scores were evident at 3 months post-surgery (mean = 12.017 ± 2.287 SE_M) compared to pre-surgery (mean = 17.274 ± 2.154 SE_M) and 6 months post-surgery (mean = 21.722 ± 1.944 SE_M), post-hoc analysis indicated this difference was not statistically significant. Similarly, there was a significant main effect of subject group ($F_{1,42} = 7.119$, p = 0.01) when the data were pooled across testing sessions where the control subjects (mean = 13.929 ± 1.634 SE,) displayed a lower strength score than the experimental subjects (mean = 20.079 ± 1.625 SE_M). However, post-hoc analysis indicated this difference was not statistically significant. No significant subject group (testing session interaction) was found ($F_{2,42} = 0.751$, p = 0.478). Therefore, harvesting the H tendons appeared to affect H strength somewhat at 3 months post-surgery but did not leave the H in a weakened state at 6 months after surgery.

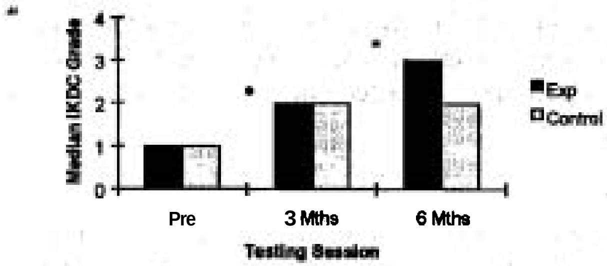
When the strength scores of the Q and H were combined to provide total strength scores, there was no significant main effect of subject group ($F_{1,46}$ = 3.729, p = 0.0629) nor any subject group x testing session interaction ($F_{2,46}$ = 0.108, p = 0.8977). However, there was a significant main effect of testing session ($F_{2,46}$ = 15.625, $p < 0.0001$) (Figure 1). Post-hoc analysis revealed that when the total strength scores for both subject groups were pooled, the strength score at 3 months post-surgery (27.4 ± 3.57 $SE_{M)}$ was significantly lower than that at pre-surgery (37.5 ± 3.27 SE_M) and at 6 months post-surgery (51.1 ± 3.26 SE_M). Also, the strength score at 6 months post-surgery (51.1 ± 3.26 SE_M) was significantly higher than that at pre-surgery (37.5 ± 3.27 SE,) and at 3 months post-surgery (27.4 ± 3.57 SE_M). These results mirrored the trends reported for the H indicating that the harvesting procedure resulted in less overall strength at 3 months post-surgery. However, full strength was regained by 6 months post-surgery.



"Indicates a significant difference between 3 months post-surgery and pre-surgery and between 3 months post-surgery and 6 months post-surgery.
#Indicates a significant difference between 6 months post-surgery and 3 months post-surgery and 6 months post-surgery and pre-surgery.

Figure 1. Mean strength scores pooled across subject group for pre-surgery and at 3 and 6 months post-surgery.

The median IKDC grades obtained for the two subject groups are presented in Figure 2. A significant main effect of testing session on IKDC grade (experimental: H2 = 20.724, $p < 0.001$,: control: H2 = 26.808, $p < 0.001$) was found where both subject groups rated their knee function significantly higher at 3 (experimental: median = 3; control: median = 3) and 6 (experimental: median = 3; control: median = 3) months post-surgery compared to pre-surgery (experimental: median = 4; control: median = 4). As expected subjective knee function increased following surgery as the athletes had a clinically stable knee that was free from any other bony pathology. It was interesting to note that, although the experimental and control subjects showed no difference in overall grade at 3 months post-surgery, at 6 months post-surgery the experimental subjects rated their knee function higher than the control subjects. Therefore, combining the H tendon harvest with the ACL reconstructive procedure may have contributed to the lower overall grade reported by the control subjects.



* Indicates a significant difference between 3 months post-surgery and pre-surgery and between 6 months post-surgery and pre-surgery for both the control and experimental subjects.
# The Median IKDC Grade is presented as 1 = D; 2 = C; 3 = B; and 4 = A.

Figure 2. Median IKDC grades for the experimental and control subjects for pre-surgery and at 3 and 6 months post-surgery.

A significant negative correlation was found between the total strength score and the IKDC grade (r = -0.28, p = 0.011). The strength score from the Q and the H also showed a non-significant trend for a negative correlation with the IKDC grade (Q: r = -0.21, p = 0.054; H: r = -0.22, p = 0.054). Therefore, lower strength deficits were associated with higher subjective ratings of knee function.

CONCLUSIONS

From the results of this study it was concluded that Q and H strength was affected by harvesting the H tendons for use in ACL reconstruction irrespective of whether the tendon was harvested from the ACL injured or uninjured limb. The surrounding musculature of the knee was found to be weakened 3 months post-surgery. However, strength increased to a level higher than pre-surgery levels by 6 months post-surgery. This change in strength was negatively correlated to subjective ratings of knee function. That is, lower strength deficits (high strength score) were associated with higher subjective rating of knee function.

The strength data in this study was analyzed using the Strength Score (Kannus et al., 1987) which is derived by assessing strength deficits of a patient's injured limb compared to an uninjured limb. The larger the deficit, the fewer the points allocated to a subject. Therefore, the experimental subjects would be expected to have a lower relative deficits than the control subjects as both limbs of the experimental subjects underwent surgical intervention. Therefore, further research is recommended to ascertain whether minimizing strength deficits in the ACL reconstructed limb by taking the graft from the contralateral limb provides greater protection for the new H graft.

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