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Prediction of Hamstring Autograft Tendon Diameter and Length for ACL Reconstruction

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ABSTRACT

Purpose: The purpose of this study was to determine whether common physical measurements in patients undergoing ACL reconstruction with autologous hamstring tendon could be used to predict autograft length and diameter. **Type of Study:** Observational **Methods:** One hundred nineteen consecutive patients undergoing hamstring autograft ACL reconstruction had the following preoperative measurements: height, weight, bilateral leg length, and bilateral thigh girth five and ten centimeters proximal to the superior pole of the patella. Correlations were evaluated between these measurements and graft length and diameter. **Results:** There was a strong correlation between leg length and hamstring autograft length ($r=0.73$; $p<0.001$). Weight ($r=0.51$; $p<0.001$) and leg length ($r=0.42$; $p<0.001$) had only moderate correlations with graft diameter. All other correlations were weak. Regression analysis demonstrated that leg length can be utilized to predict hamstring autograft tendon length to within 20 mm and weight can be utilized to predict graft diameter to within 1.2 mm using regression equations. **Conclusions:** In conclusion, several simple measurements correlate with doubled semitendinosus and gracilis tendon autograft length and diameter. This new information may prove useful to surgeons who desire hamstring autografts of a certain diameter or of a long length. **Level of Evidence:** II

Key Words: hamstring tendons, autograft, anterior cruciate ligament reconstruction

Introduction

Anterior cruciate ligament reconstruction is a common orthopaedic procedure^{1,2}. The use of bone-patella tendon-bone autografts for ACL reconstruction is a successful time-tested

57 technique¹⁻⁴. However, the potential graft harvest site morbidity associated with this patellar
58 tendon grafts has lead to the development of alternative graft sources¹. A variety of autograft
59 and allograft tissues have been used. Four-stranded hamstring autografts have been
60 demonstrated to be successful grafts for ACL reconstruction¹⁻⁵.

61 The diameters and lengths of doubled semitendinosus and gracilis autografts can be quite
62 variable. There may be situations where different surgeons may desire larger diameter grafts.
63 One situation where some surgeons may desire a larger diameter graft could include ACL
64 reconstructions in heavier athletic patients. Revision ACL reconstructions often pose special
65 challenges where a larger diameter graft may be useful⁶.

66 Hamstring autografts of longer length may also be useful for some surgeons. Fixation
67 techniques outside of the tibial tunnel such as staples and some proprietary fixation devices
68 require that the grafts exit the tibial tunnels for a certain distance.

69 Currently, there exists no method to determine hamstring autograft diameter and length
70 prior to ACL surgery. It may be ideal to have a simple method to calculate approximate
71 hamstring autograft and length preoperatively for some surgeons. This preoperative knowledge
72 may allow surgeons the opportunity to choose an alternative graft if the hamstring autograft
73 specifications will not meet their desires for a given patient.

74 Although preoperative thirty degree flexion lateral x-rays of the knee have been shown to
75 be accurate predictors of patella tendon length⁷, we are unaware of any study that has attempted
76 to predict the diameters or lengths of hamstring autografts for ACL reconstruction. The purpose
77 of this study was to evaluate whether simple preoperative measurements would correlate with the
78 diameters and lengths of doubled semitendonosus and gracilis tendon autografts.

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80 **Methods and Materials**

81 One hundred nineteen consecutive patients undergoing ACL reconstruction using
82 hamstring autograft tendons were included in the study. Numerous preoperative measurements
83 were obtained for each patient. Measurements of height and weight were obtained at the surgery
84 center. Thigh girth measurements were made on each lower extremity. They were made with a
85 measuring tape at distances of five and ten centimeters from the superior poles of the patellas
86 with the knees in extension. Leg length measurements of the involved leg were made by
87 measuring the distances from the anterior superior iliac spines to the medial malleoli.

88 The hamstring tendon autografts were harvested in a uniform fashion. The
89 semitendonosus and gracilis tendons were detached from their insertion into the proximal tibia.
90 The ends were whipstitched and a closed tendon stripper was utilized to detach the tendons from
91 their musculotendonous junctions. After removing muscle bluntly, the two tendons were folded
92 to form a four stranded graft. The functional length of the graft was measured. This was defined
93 as the length that all four strands were present. This is equates to one half the length of the
94 shorter of the two tendons. The reason for this is that tibial-sided fixation needs to include all
95 four strands of the graft to be effective.

96 Graft diameter was determined after the free ends of each graft were whipstitched with
97 number two nonabsorbable suture. The grafts were passed through sizing cylinders on a sizing
98 block with incremental size changes of 0.5 mm. The smallest size tube that the graft could be
99 passed through was considered the graft diameter.

100 Statistical analysis was performed with regression analysis to determine correlations
101 between the numerous measurements and the graft diameters and lengths. Stepwise algorithms

102 were also used to select significant predictors of graft length and diameter. Regression equations
103 were generated to attempt to predict graft diameter and length based on given measurements.

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105 **Results**

106 There were 54 females and 65 males in the study. The leg length range was 74-116 cm
107 and the weight range was 102-320 lbs. A summary of the results is been included in Table 1.

108 Correlations with graft length are summarized in Table 2. Leg length had the strongest
109 correlation with graft length ($r=0.73$, $p<0.001$). Regression analysis was performed for leg
110 length with respect to graft length ($r^2 =0.54$).

111 The regression equation that allows prediction of graft length based on leg length is:
112 Graft Length = $-12.79 + (1.557 \times \text{Leg Length})$. This is based on 95% confidence intervals with a
113 graft length of plus or minus 20 mm (95% CI = ± 20 mm).

114 Correlations with graft diameter are summarized in Table 3. Patient weight most strongly
115 correlated with graft diameter ($r=0.51$, $p<0.001$). Leg length had lesser correlation with graft
116 diameter ($r=0.42$, $p<0.001$).

117 Regression analysis was again performed once with all variables and again using
118 stepwise algorithm. In stepwise selection, weight ($p < 0.001$) and leg length ($p = 0.02$) were
119 significant predictors of graft diameter when used in combination ($r^2 = 0.31$, $p<0.001$). The
120 regression equation using both weight and leg length as predictors is as follows:

121 Graft Diameter = $4.80 + (0.07 \times \text{weight}) + (0.21 \times \text{leg length})$

122 The 95% confidence interval when using leg length and weight (within the given
123 parameters) to predict graft diameter is ± 1.2 mm (CI 95% = ± 1.2 mm).

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125 **Discussion**

126 ACL reconstruction with hamstring autograft tendons is a popular procedure in
127 orthopaedics. Various minimum diameters and lengths of doubled semitendinosus and gracilis
128 autografts may be important to some surgeons and may be critical for certain surgical techniques
129 and procedures.

130 We evaluated the correlations of numerous easy preoperative measurements with the
131 diameters and lengths of doubled semitendinosus and gracilis autografts for ACL reconstruction.
132 Of these numerous measurements, there were only a few useful correlations with graft diameter
133 and length. First, patient leg length demonstrated a strong correlation with graft length. This
134 was the best correlation of the various measurements. Utilizing 95% confidence intervals, a
135 regression equation was calculated that allows leg length to predict graft length within 20 mm.

136 Graft diameters demonstrate moderate correlations with preoperative patient weights. A
137 somewhat lesser correlation was leg length with graft diameter. However, with regression
138 analysis and stepwise selection, leg length and weight together were significant predictors of
139 graft diameter. The diameter of the graft is correlated to both leg length and patient weight, and
140 this was statistically significant. With 95% confidence intervals, the calculated regression
141 equation can be used to predict the diameter of the graft to within 1.2 mm given the leg length
142 and the weight of the patient.

143 The ability to predict graft diameter and length may be useful for certain surgical
144 techniques. Longer graft lengths may necessary for tibial-sided fixation outside of the tibial
145 tunnel. It would be helpful to know if a given patient's hamstring autograft would be long
146 enough to allow this type of fixation. If the expected graft length was not adequate, the surgeon
147 could choose an alternative graft type. Further, minimum graft diameters might be desired for

148 revision ACL reconstruction. Previous tunnels and fixation may necessitate a larger diameter
149 graft in a revision situation. If this were the case, an estimated hamstring graft diameter could
150 aid in graft selection. Information regarding graft diameter may also be helpful to surgeons who
151 may desire larger diameter grafts for certain patients involved in given sports or working in more
152 laborious occupations. Last, smaller diameter grafts may be desirable for some surgeons
153 performing ACL reconstruction in skeletally immature patients.

154 The main limitations of this study involve the accuracy of some of the preoperative
155 measurements. Leg length as measured from the anterior superior iliac spine to the medial
156 malleolus is not the most accurate way to measure leg length. Also, measurements of weight did
157 not take into account per cent body fat. A measure of lean body mass may have demonstrated
158 different results. However, the chosen measurements for the study were simple ones that could
159 be performed with facility in an office setting.

160 In summary, doubled semitendinosus and gracilis graft length for ACL reconstruction is
161 strongly associated with leg length. For techniques that necessitate it, graft length can be
162 predicted after measuring leg length. Further, graft diameter can be predicted with
163 measurements of leg length and patient weight. Although these are not precise calculations, we
164 feel that the graft data that can be predicted may be useful for preoperative planning for ACL
165 reconstruction with hamstring autograft tendons.

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Table 1: Summary of Results

		Avg. Height (inches)	Avg Weight (lbs)	Avg Leg Length (cm)	Avg Age	Average Graft Length (mm)	Average Graft Diameter (mm)
<u>Number of Females</u>	54	63.25	143.48	85.58	24.41	119.75	7.52
<u>Number of Males</u>	65	64.86	190.75	93.99	26.36	134.18	8.17

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Table 2: Correlation between graft length and the specified characteristics

Characteristic	r value
age	0.0584
weight	0.4376
height	0.575
Leg length	0.7343
involved~5cm	0.2034
involved~10cm	0.1231

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Table 3: Correlation of Graft Diameter with Specified Characteristics

Characteristics	r value
age	-0.0437
weight	0.5118
height_in	0.3903
Leg length	0.4177
involved~5cm	0.3462
involved~10cm	0.3447

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