ACL GROWTH WITH AGE IN PEDIATRIC PATIENTS: AN MRI STUDY

Emily Niu, MD¹, Danielle Putur, BA²

¹Children's National Medical Center, Washington, DC, USA, ²George Washington University Medical Center, USA

Background

The incidence of anterior cruciate ligament (ACL) injury is steadily increasing in skeletally immature patients [1-7]. As a result, surgical approaches to reconstruction of the ACL without compromising the physis have been developed [6, 8, 9]. It is essential to understand how the native ACL changes with patient growth and age, in order to better understand how grafts might serve patients as they continue to grow. The purpose of this study is to characterize the morphological change over time of different ACL parameters in the pediatric and adolescent population based on serial magnetic resonance imaging (MRI).

Methods

After receiving Institutional Review Board approval, the patient cohort was identified retrospectively from a database of all patients who had a routine magnetic resonance imaging (MRI) of the knee between July 2005 and February 2017. Patients aged 0 to 18 years at the time of their initial MRI, who had undergone at least two serial MRI examinations of the same knee at least 4 months apart for reasons other than ACL tear were included. Patients were excluded if they had a fracture of the distal femur or proximal tibia, congenital condition that affects the knee, deformity of the femur or tibia, or if they have a pathologic process (e.g. tumor) that disrupts the anatomy of the distal femur or proximal tibia.

The parameters measured included physeal status, length of the ACL, diameter of the ACL in the sagittal and coronal plane, ACL-tibial inclination angle, notch width index, the midpoint of the ACL tibial attachment, anterior to posterior dimension of the tibia, and tibial epiphyseal height. A Pearson correlation coefficient was calculated to determine the strength of correlation of each parameter relative to age. Growth curves were calculated for individual parameters, which produced a predictive model for the rate of growth of the ACL at different ages.

Results

162 knees in 147 patients (365 MRI studies) were identified to have had serial MRI of their knee. 50.3% of patients were female. Ages at time of MRI ranged from 1.3 to 21.7 years (average 13.5 years, SD 3.60). The Pearson correlation coefficient for each parameter showed statistically significant relationship relative to age. The ACL grows in length and diameter with age. Younger patients had more oblique, anteriorly attached ACLs compared to older patients.

The growth model for ACL length shows three distinct phases of growth: patients age 1.5 to 5.75 years average 2.25 mm of growth per year; patients aged 6 to 11.5 average 1.46 mm of growth per year; growth begins to plateau at age 11.75, stopping by age 18.5 years. The growth model for ACL sagittal diameter shows an average of 0.45 mm of growth per year between 1.5 and 14.5 years old, after which growth slows until it stops at age 18.75. The ACL coronal diameter model shows an average of 0.22 mm of growth per year between 1.5 and 18.75 years old, with growth completion by age 18.75.

ANCOVA was used to assess the difference in growth rates between men and women. Growth rates for ACL length, ACL diameter in the coronal plane, transcondylar width, posterior border, center, and width of ACL-tibial attachment, and anterior-to-posterior dimension of the tibia are significantly different in men and women. Namely, for all significant differences, men had faster growth rates than women.

Conclusions/Significance

In the skeletally immature patient, the ACL grows in length and diameter in a predictable fashion until age 18. This model aids clinicians in predicting normal ACL parameters for reconstruction procedures in the skeletally immature patient. It may have important implications for ACL reconstruction in very young patients.

Measurement	Pearson R	p-value
ACL length	+0.699	<0.001
ACL sagittal diameter	+0.710	<0.001
ACL coronal diameter	+0.652	<0.001
Intercondylar notch width	+0.276	<0.001
Transcondylar width	+0.597	<0.001
Notch width index	-0.284	<0.001
ACL inclination angle	+0.650	<0.001
ACL anterior border	+0.581	<0.001
ACL posterior border	+0.698	<0.001
ACL center of attachment	+0.677	<0.001
Width of tibial insertion	+0.422	<0.001
Tibial epiphysis AP dimension	+0.681	<0.001
Tibial epiphysis vertical height	+0.479	<0.001

Pearson R correlations between parameters and age

Measurement	Male Linear Regression		Female Linear Regression		ANCOVA
	B (mm/year)	p-value	B	p-value	p-value
ACL length	1.207	<0.001	0.842	<0.001	0.001
ACL width, coronal	0.246	<0.001	0.181	<0.001	<0.001
Transcondylar width	1.614	<0.001	0.981	<0.001	<0.001
ACL center of attachment	0.708	<0.001	0.626	<0.001	<0.001
Width of ACL tibial insertion	0.337	<0.001	0.240	<0.001	0.004
Tibial epiphysis AP dimension	1.255	<0.001	0.887	<0.001	<0.001

Parameters with significantly faster rate of growth in males vs females

Figure 1. ACL length growth curve: age v change in length of ACL

Figure 2. ACL sagittal diameter growth curve: age v change in sagittal diameter of ACL.

Figure 3. ACL coronal diameter growth curve: age v change in sagittal diameter of ACL.

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The Orthopaedic Journal of Sports Medicine, 7(3)(suppl 1)

DOI: 10.1177/2325967119S00088

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