

Microstructural Evidence Supporting the Use of the Quadriceps Tendon in Adolescent ACL Reconstruction: A Comparison with the Semitendinosus Tendon

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INTRODUCTION:

Anterior cruciate ligament (ACL) reconstruction using the semitendinosus tendon (ST) in adolescent patients has been associated with higher failure rates, reported to be as high as 28%, compared to the general failure rate of under 5% for primary ACL reconstruction. The cause for this disparity remains unclear. In recent years, the quadriceps tendon (QT) has gained attention as an alternative graft due to its potential biomechanical advantages. Tendons are known to strengthen with growth through increased collagen content, enhanced cross-linking, and changes in fibril diameter, particularly in animal models. However, studies investigating these microstructural changes in human tendons remain limited.

We hypothesized that tendon maturation differs between QT and ST, with QT maturing faster and having larger collagen fibril diameters during growth. This study aimed to examine age-related microstructural changes in QT and ST, to evaluate their suitability as ACL grafts in adolescent patients.

METHODS:

Small amounts of QT (18 patients) and ST (18 patients) were collected during several knee surgeries in 36 patients of various ages. We divided the 18 samples into three groups based on the state of the epiphyseal plate on MRI at the distal femur of the patients as follows: the immature group had open epiphyseal plates (the epiphyseal plate was >1.5 mm thick), the young group had patients <20 years of age, with the epiphyseal plates closed, and the adult group had all patients >20 years of age, with the epiphyseal plates closed. The samples were examined at x8000 magnification under a transmission electron microscope. Minimum collagen fibril diameters were measured from these cross-sections using Image J software. At least four slides from each sample were evaluated, and more than 100 collagen fibrils on each slide were evaluated.

The intra-observer reliability of the measurements for the collagen fibrils of tendon tissue, determined using the intraclass correlation coefficient (ICC), was 0.849 and 0.955 respectively. The inter-observer reliability was 0.949 and 0.991. All measurements were analysed using SPSS version 24.0 software. This study was approved by our hospital's ethics committee, and the patients were informed that data from the case would be submitted for publication, and gave their consent.

RESULTS:

The average age of QT group and ST group are 12.3±0.8, 11.8±3.7 years in Immature group, 15.8±1.0, 15.7±1.5 years in Young group, 29.8±11.3, 37.7±5.3 years in Adult group.

The average collagen fibril diameters of QT group and ST group are 89.7±14.4, 73.1±10.5 nm (P=0.04) in Immature group, 94.8±16.4, 90.8±15.0 nm (P=0.67) in Young group, 107.2±12.1, 105.8±14.9 nm (P=0.85) in Adult group.

DISCUSSION AND CONCLUSION:

This study provides novel microstructural evidence that supports the use of the quadriceps tendon as a more suitable graft option than the semitendinosus tendon for ACL reconstruction in adolescent patients. The early maturation of the quadriceps tendon may offer biomechanical advantages during a critical period of skeletal development and rehabilitation.

Table 1 Patient characteristics

		QT	ST	P value
Age (years)	Immature group	12.3 ± 0.8	11.8 ± 3.7	0.75
	Young group	15.8 ± 1.0	15.7 ± 1.5	0.83
	Adult group	29.8 ± 11.3	37.7 ± 5.3	0.16
Sex (M: F)	Immature group	4 : 2	3 : 3	N/A
	Young group	4 : 2	4 : 2	N/A
	Adult group	3 : 3	4 : 2	N/A
Height (cm)	Immature group	137.8 ± 10.8	147.3 ± 18.9	0.31
	Young group	169.4 ± 8.0	167.7 ± 7.5	0.83
	Adult group	167.8 ± 8.6	166.5 ± 8.3	0.8
Body weight (kg)	Immature group	37.3 ± 6.8	43.3 ± 14.0	0.37
	Young group	64.1 ± 13.9	59.9 ± 9.5	0.59
	Adult group	60.2 ± 4.3	61.7 ± 5.8	0.63
BMI (kg / m ²)	Immature group	19.6 ± 2.5	19.4 ± 2.5	0.87
	Young group	22.1 ± 3.2	21.2 ± 2.2	0.55
	Adult group	21.4 ± 1.4	22.3 ± 2.0	0.41

Table 2 Average collagen fibril diameter

	QT	ST	P value
Immature group (nm)	89.7 ± 14.4	73.1 ± 10.5	0.04
Young group (nm)	94.4 ± 16.4	90.8 ± 15.0	0.67
Adult group (nm)	107.2 ± 12.1	105.8 ± 14.9	0.85

