The Influence of Femoral Technique for Graft Placement on Anterior Cruciate Ligament Reconstruction Using a Skeletally Immature Model with a Rapidly Growing Physis

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Introduction

Anterior cruciate ligament (ACL) injury in the skeletally immature individual is being recognized with increasing frequency. Historically, nonoperative treatment of midsubstance ACL injuries in skeletally immature individuals has not been favorable. Despite many reports of successful ACL reconstruction, many orthopaedic surgeons are still reluctant to perform ACL reconstructive procedures in the skeletally immature individual because of clinical reports of subsequent growth abnormalities and a general lack of understanding regarding the physiologic consequences of ACL reconstruction in these patients.

Current clinical studies support the use of anatomic ACL reconstructive techniques via either paraphyseal, transphyseal, or epiphyseal graft positioning with either metaphyseal or epiphyseal graft fixation. Although there is a consensus that reconstructions via fixation devices or bone grafts that traverse the physis carry a high risk for growth abnormalities and are inappropriate, it is not known which technique of ACL reconstruction provides the least risk and best restores the anatomy and function of the ACL in the growing child.

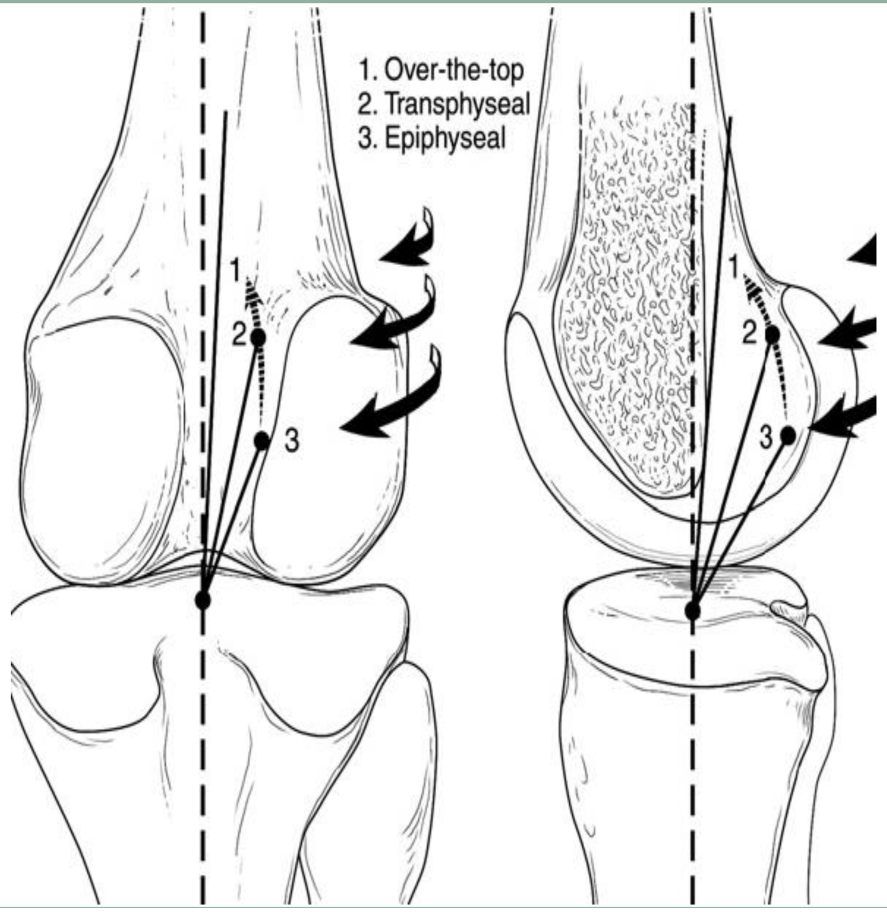
Objectives

The purpose of this study was to evaluate three different femoral techniques of anterior cruciate ligament (ACL) reconstruction using a skeletally immature model.

Methods

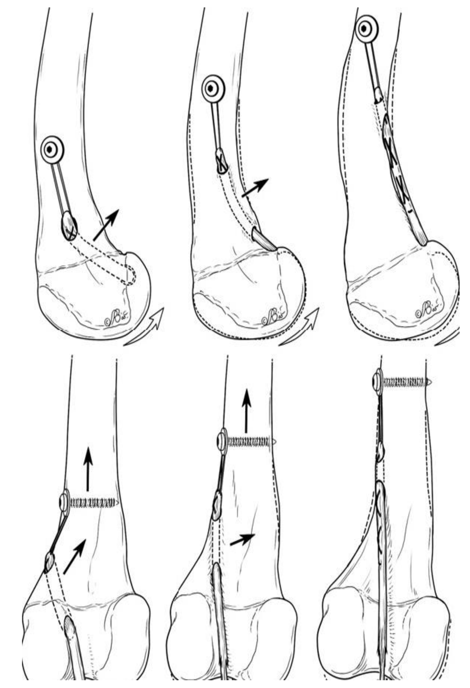
A soft-tissue autograft ACL reconstruction was performed in 25 skeletally immature subjects using a central transphyseal tibial tunnel and 1 of 3 femoral techniques: epiphyseal, over the top, or transphyseal.

The contralateral knee served as a control. Postoperatively , the subjects were evaluated by gross inspection, plain radiographs, photography, magnetic resonance imaging, and hitomorphometry.



Results

There were no significant differences in femoral longitudinal growth; however tibial growth was significantly greater on the experimental side relative to controls (P= .001). Angular and rotational deformities were noted on the femoral side but not on the tibial side. The epiphyseal technique resulted in less angular deformity and most closely maintained the anatomic position of the ACL graft with growth; however, this technique exhibited increased femoral rotational deformity. All techniques exhibited a high rate of graft failure. Magnetic resonance imaging revealed chondral and subchondral injuries to the lateral femoral condyle, most frequently in the epiphyseal group.



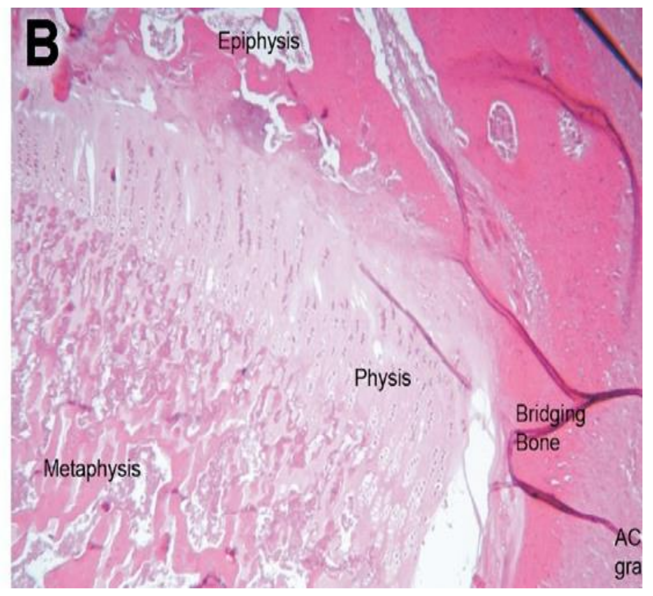


TABLE 1. *Femoral and Tibial Medial and Lateral Lengths After Growth*

Measurement	Epiphyseal	Transphyseal	Over the Top	Control	*P* Value
Medial femoral length (mm)	183.55 ± 7.99	180.60 ± 9.54	178.04 ± 10.15	177.97 ± 9.51	.010
Lateral femoral length (mm)	181.61 ± 10.74	179.54 ± 10.26	177.35 ± 9.52	179.11 ± 9.46	.484
Medial tibial length (mm)	194.97 ± 9.59*	194.84 ± 9.62*	189.52 ± 11.05*	184.81 ± 10.13	≤.001
Lateral tibial length (mm)	192.65 ± 9.92*	192.69 ± 8.46*	187.29 ± 10.26*	182.32 ± 9.73	≤.001

NOTE. Data are presented as mean ± SD.
*Statistically significant difference from respective control.

TABLE 2. *Femoral Angulation: Comparison by Procedure*

Comparison	Epiphyseal v Control	Transphyseal v Control	Over the Top v Control	Transphyseal v Epiphyseal	Over the Top v Epiphyseal	Transphyseal v Over the Top
Distal femoral angulation:						
Coronal						
Difference of means (°)	5.0* valgus	9.7* valgus	10.0* valgus	4.4* valgus	5.0* valgus	−0.6 valgus
Unadjusted *P* value	.001	≤.001	≤.001	.022	.010	.736
Femoral diaphyseal angulation:						
Sagittal						
Difference of means (°)	5.1* apex anterior	5.9* apex anterior	5.0* apex anterior	0.8 apex anterior	−0.1 apex anterior	0.9 apex anterior
Unadjusted *P* value	≤.001	≤.001	≤.001	.612	.941	.575
Distal femoral angulation:						
Sagittal						
Difference of means (°)	4.7* procurvatum	13.0* procurvatum	7.0* procurvatum	8.3* procurvatum	2.3 procurvatum	6.0* procurvatum
Unadjusted *P* value	.005	≤.001	≤.001	≤.001	.253	.008

*Statistically significant difference.

TABLE 3. *Comparisons of Femoral Rotation After Growth*

Femoral Rotation	Epiphyseal v Control	Transphyseal v Control	Over the Top v Control	Transphyseal v Epiphyseal	Over the Top v Epiphyseal	Transphyseal v Over the Top
Difference of means (°)	7.6* ER	6.3* ER	3.5 ER	−1.3 ER	−4.1 ER	2.8 ER
Unadjusted *P* value	≤.001	.005	.094	.607	.120	.300

Abbreviation: ER, external rotation of distal femur relative to proximal femur.
*Statistically significant difference.

Conclusion

From the results of our study, we cannot advocate any single femoral reconstructive technique. An epiphyseal femoral technique may reduce the risk of angular deformity and allow a more optimal femoral graft position after growth as opposed to transphyseal and over-the-top techniques. However, the epiphyseal technique may possess an increased risk for rotational deformity, physeal injury, and articular surface injury.

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