Ultrasonography and Statistical Shape Modeling: Analyzing Femoral Trochlea Bone Shape Post-ACL Reconstruction

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INTRODUCTION

- Femoral bone morphology alterations after ACL reconstruction are linked to increased risk of injury and disease.
- Traditional bone shape assessments are inaccessible and do not capture the full complexity of the bone shape.

Purpose: To develop a 2D US-based statistical shape model for comparing bone shape features in individuals with and without ACLR.

METHODS

Design: Case-control study, secondary analysis

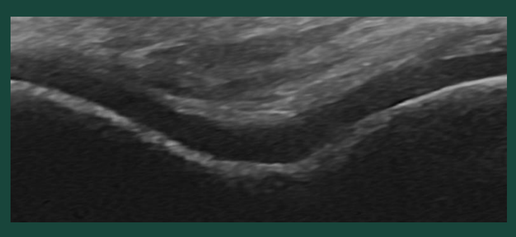
- Femoral articular cartilage images were acquired via ultrasound and manually segmented.
- Femoral trochlear bone lines were registered and a PCA was performed.
- 5-fold cross validation confirmed the reconstruction accuracy of the SSM.
- CART models were developed to classify knee types using bone shape feature scores.

Participant Demographics

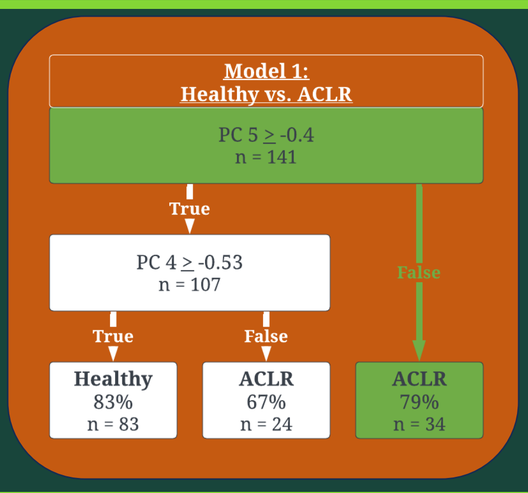
	ACLR	Control	*P* value
n	20	28	-
Females, %	75%	64%	-
Age, y	20.2±2.1	20.5±1.7	0.57
Height, cm	168.2±7.3	170.8±10.6	0.37
Mass, kg	69.7±16.6	69.6±18.5	0.98
Months post-ACLR	37.0±26.6	-	-

Ultrasound can be used to quantify *femoral trochlea bone shape* and can be used to classify **knee morphology after ACLR**.

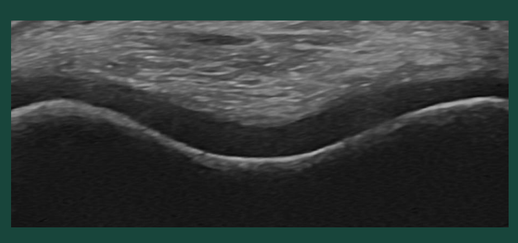
ACLR



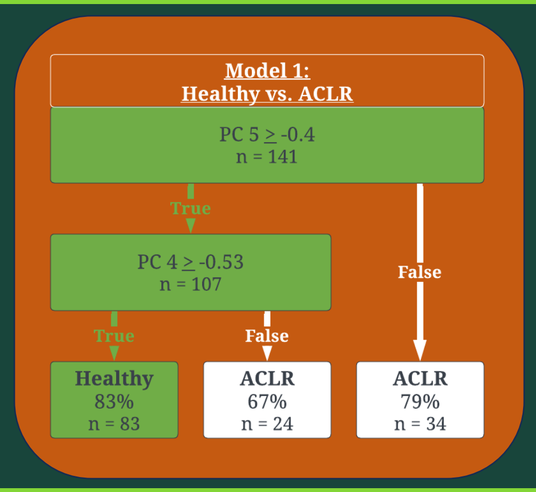
PC 4 Score: -2.38
PC 5 Score: -0.97



Healthy



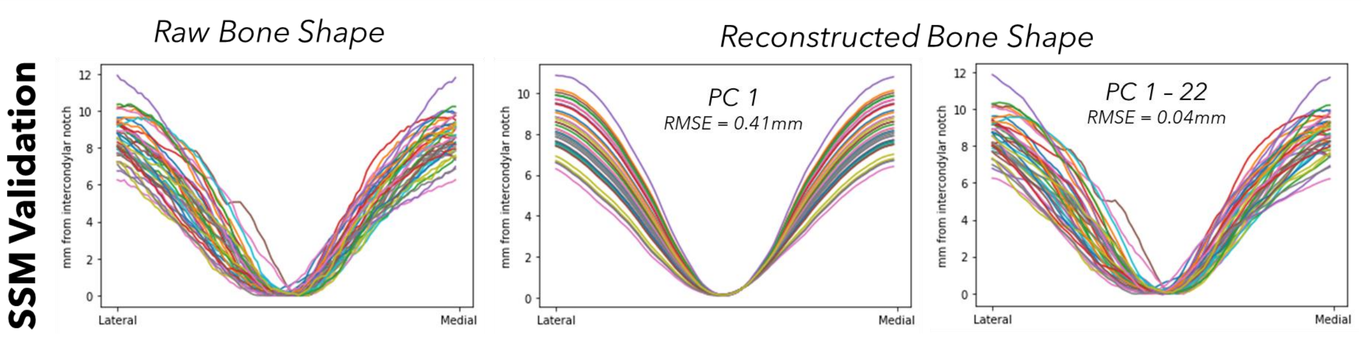
PC 4 Score: 1.67
PC 5 Score: 2.01



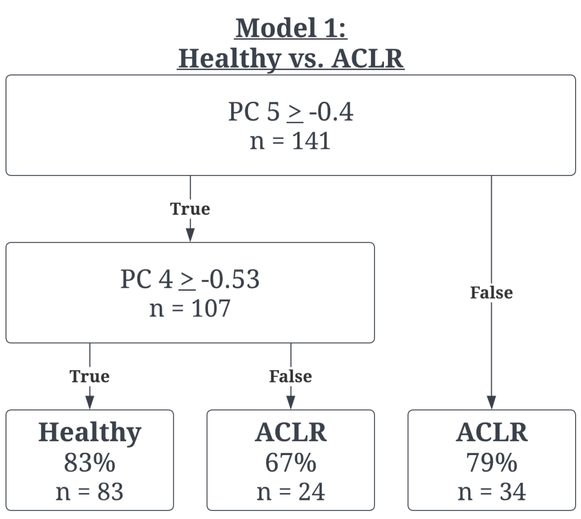
@Ajparmar_ @ArjunParmar9 @Ajparm

RESULTS

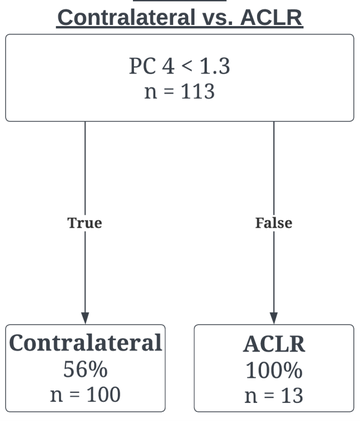
- The optimal number of shape scores was 22. Using the 22 components that explained the most variance in the model to reconstruct the bone shape, the reconstruction error was 0.04mm.
- PC scores 4 & 5 can be used to classify healthy and ACLR limbs with moderate accuracy.
- PC score 4 classifies contralateral and ACLR limbs with poor accuracy indicating bilateral similarities after ACLR



CART Model Development

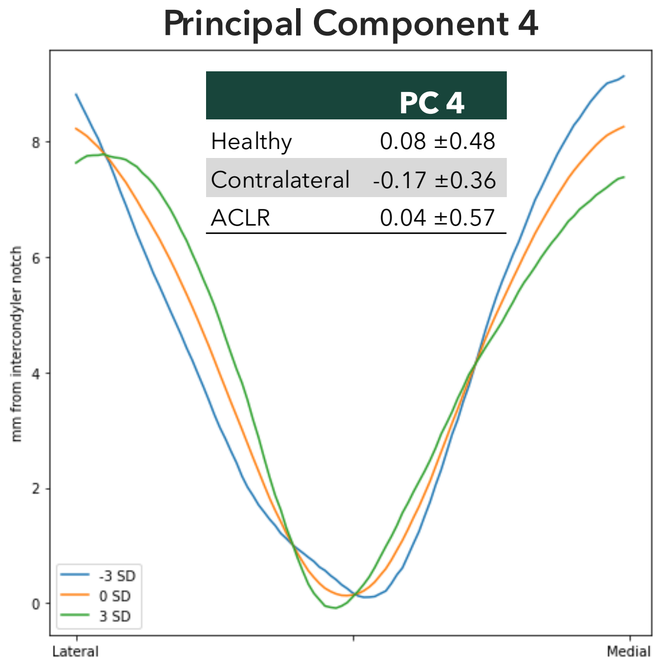


	Model 1	Model 2
Accuracy	76%	57%
Specificity	82%	100%
Sensitivity	75%	23%



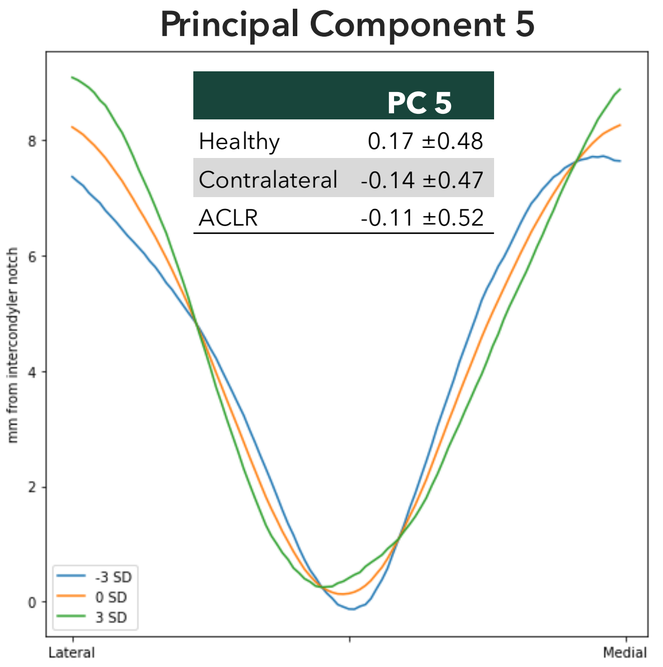
Principal Component 4

	PC 4
Healthy	0.08 ±0.48
Contralateral	-0.17 ±0.36
ACLR	0.04 ±0.57



Principal Component 5

	PC 5
Healthy	0.17 ±0.48
Contralateral	-0.14 ±0.47
ACLR	-0.11 ±0.52



DISCUSSION

- The SSM developed demonstrated excellent bone shape reconstruction accuracy.
- Femoral trochlear bone shape was different between an ACLR limb and a healthy control limb, but not between ACLR and contralateral limbs.
- Future research should track longitudinal bone shape changes related to osteoarthritis after ACLR using the US based SSM.
- Future research should determine if early measures of bone shape predict future development of radiographic or symptomatic knee OA