Is Posterior Tibial Slope a Predictor of Hamstring Autograft Failure in Primary ACLR?

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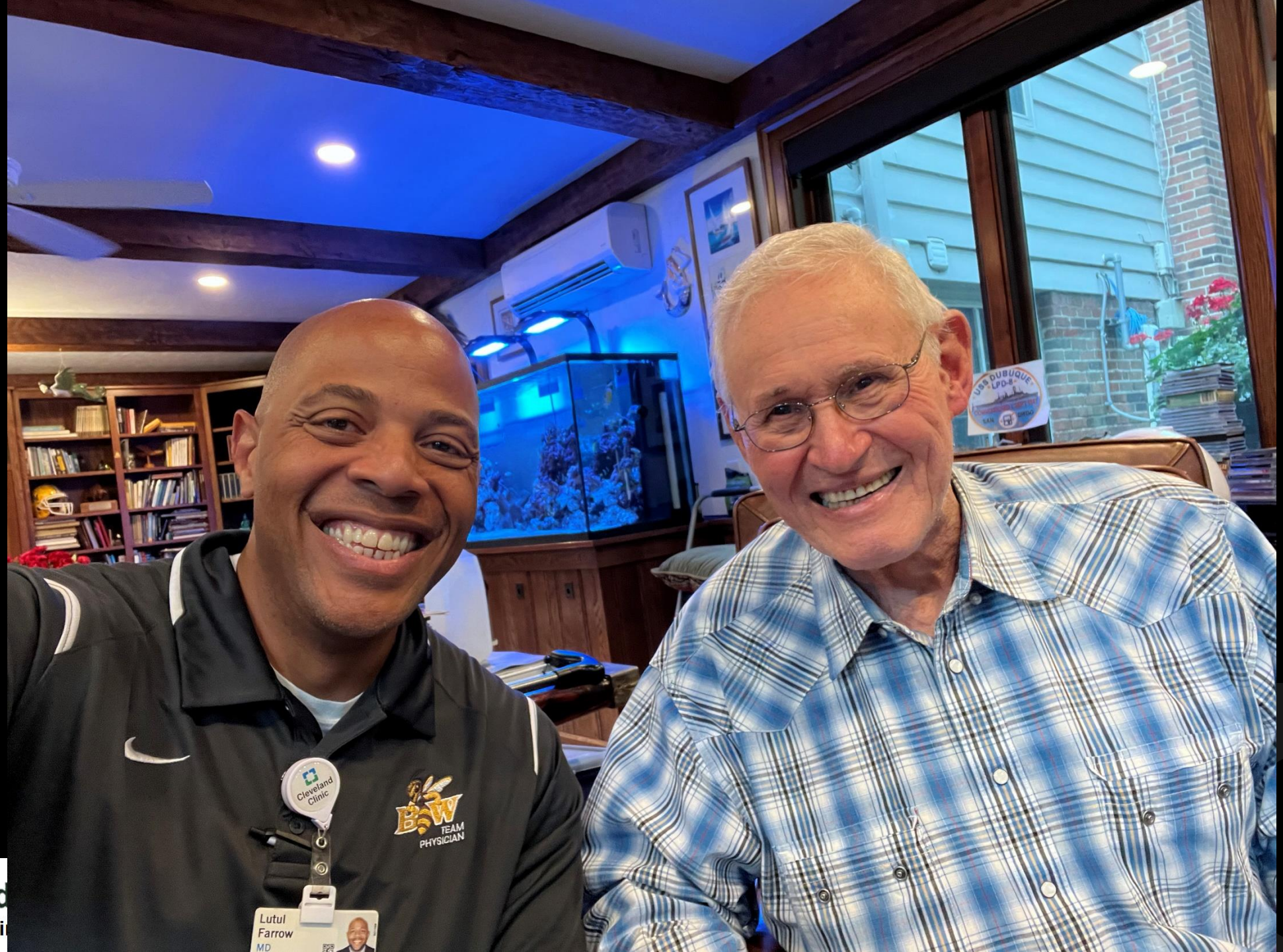
I have received nothing of value in relation to this presentation

- Patellar instability research funding
  - OREF
  - Dept of Defense
  - AANA
- Fellowship Support
  - Smith& Nephew
  - Arthrex



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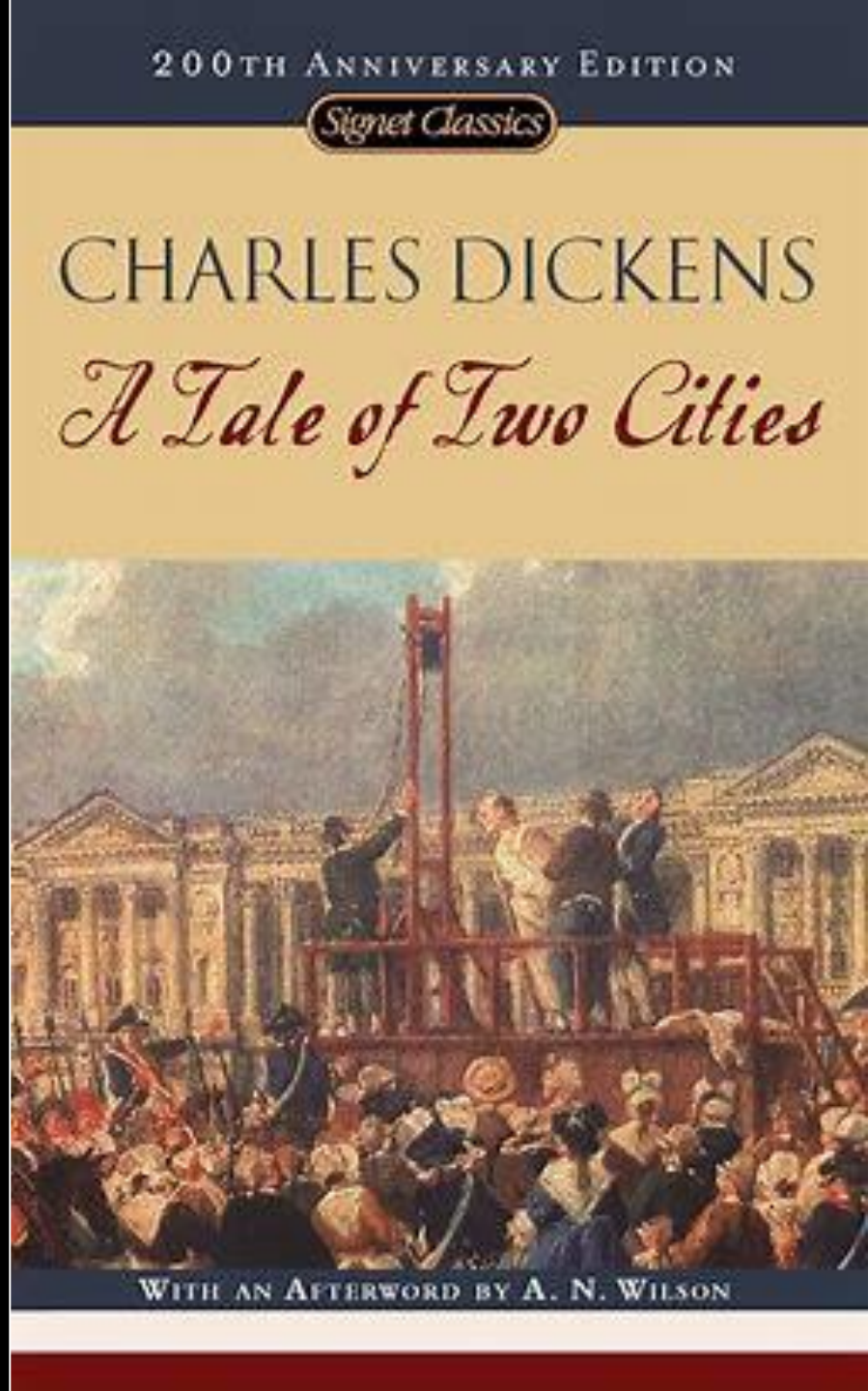
Background

- A tale of two cities
  - 132 miles (212 Km) apart
  - Lots of revisions, no slope correction
  - Lots of revisions, slope correction
- What's the right answer?
- Can we trust measurements?
- Does PTS really matter?



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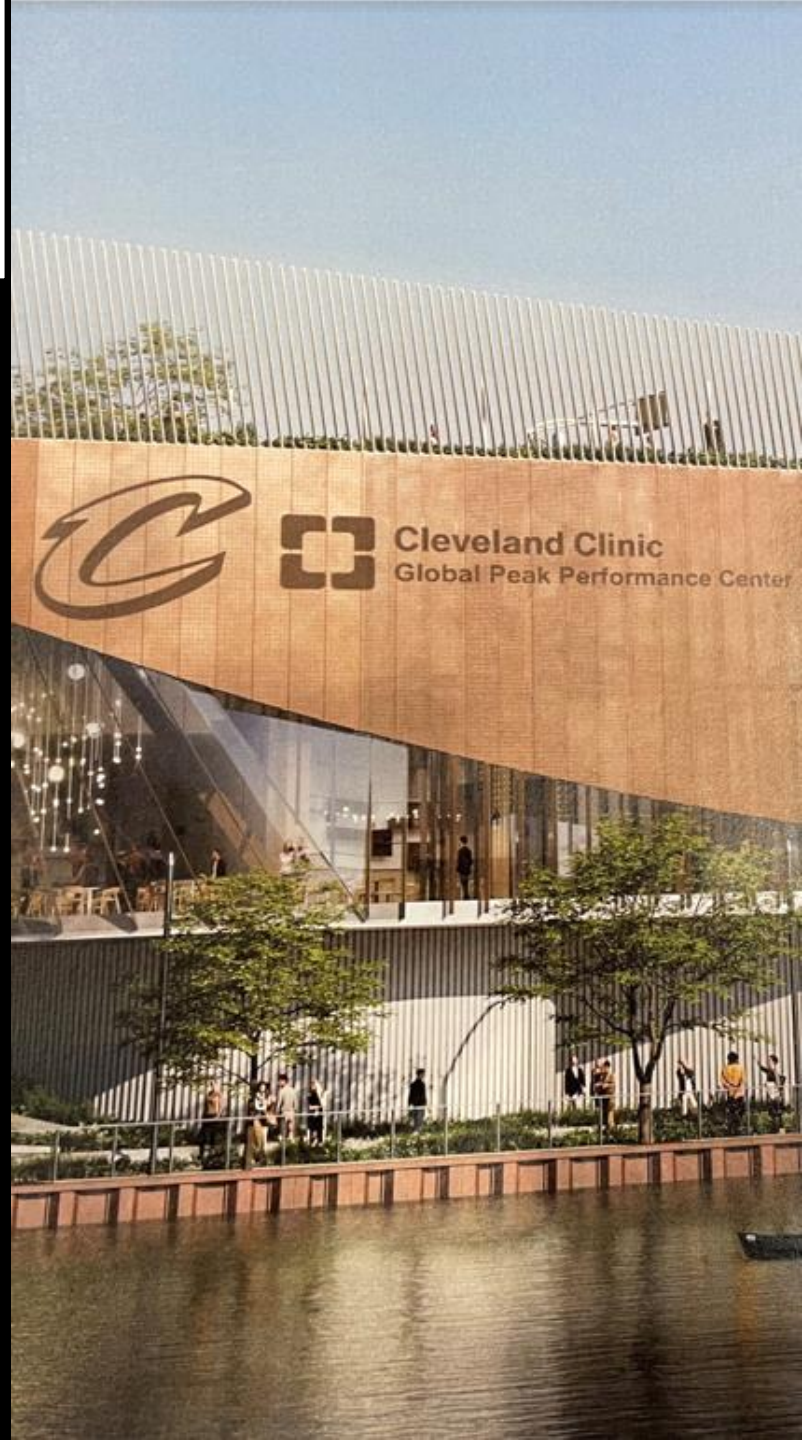
Posterior Tibial Slope and Further Anterior Cruciate Ligament Injuries in the Anterior Cruciate Ligament–Reconstructed Patient

LOE: 3

- AJSM 2013
- Webb et al
- 200 **hamstring ACLRs** – 50 ruptures
  - PTS: further surgery
    - 9.9° vs no surgery: 8.5°
  - Graft and contralateral tear
    - PTS mean 12.9°
  - PTS > 12°
    - 5-fold increase in rupture risk



Closing-Wedge Posterior Tibial Slope–Reducing Osteotomy in Complex Revision ACL Reconstruction

LOE: 4

- OJSM 2023
- Multicenter, 10-yr study
  - N = 23 total patients
- Outcomes:
  - PTS reduced from 14° to 4°
  - 3 failures (13%)
  - 6 reoperations (26.1%)
  - Low PROM scores
- Conclusion: consider in patients w/ PTS >12° and >1 ACLR failure

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[The tibial slope. Proposal for a measurement method].

Genin P [1], Weill G , Julliard R

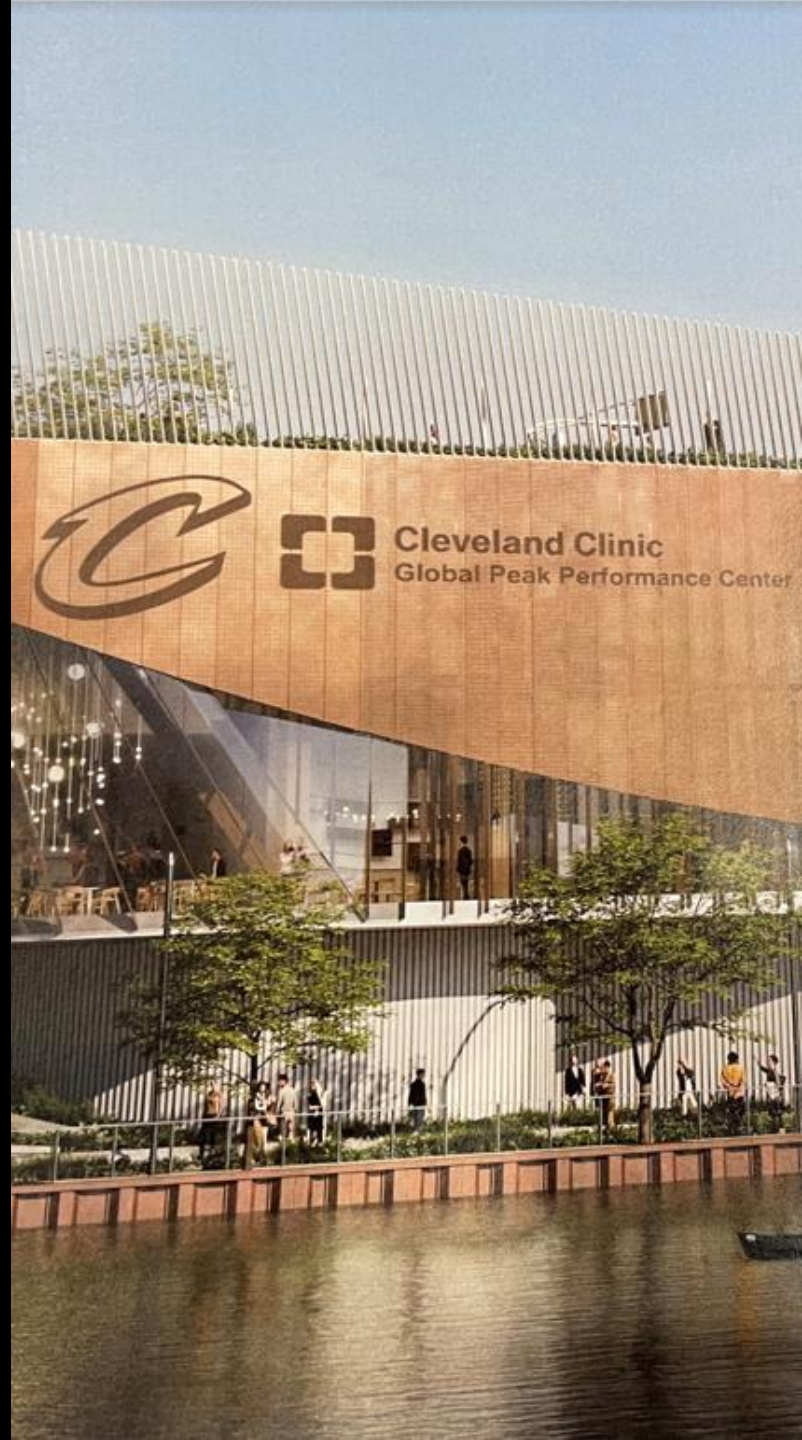
- J Radiol 1993
- Lateral radiograph PTS measurement

Posterior tibial slope in the normal and varus knee.(Article)

Matsuda, S., Miura, H., Nagamine, R., Urabe, K., Ikenoue, T., Okazaki, K., Iwamoto, Y.

Department of Orthopaedic Surgery, Faculty of Medicine, Kyushu University, Fukuoka City, Japan

- AJKS 1999
- MRI measurements
  - Medial tibial slope **10.7° (range 5-15.5°)**
  - Lateral tibial slope **7.2° (0-14.5°)**



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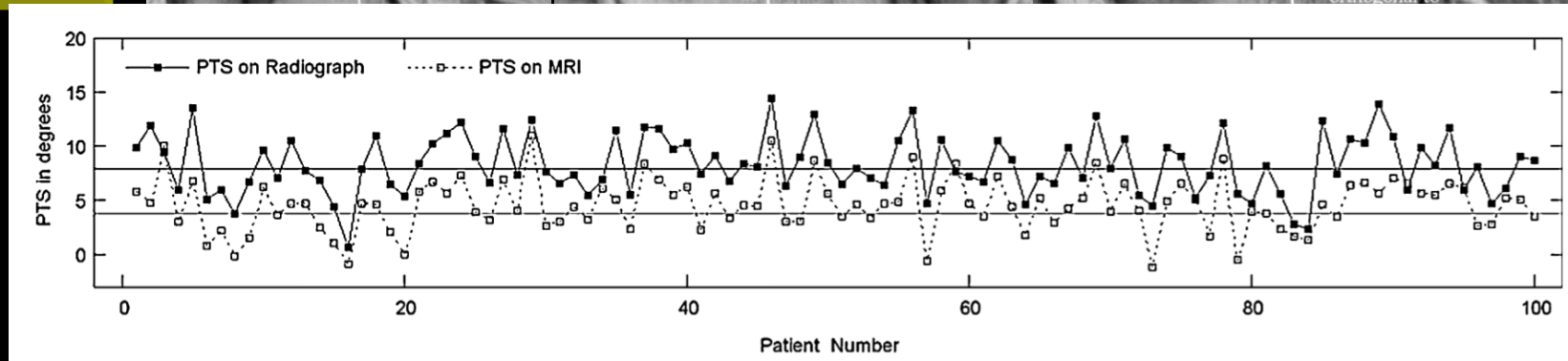
Novel Measurement Technique of the Tibial Slope on Conventional MRI

Robert Hudek MD, Silvia Schmutz PhD,
Felix Regenfelder MD, Bruno Fuchs MD, PhD,
Peter P. Koch MD

LOE: 3

- **X-ray is may over-estimate**
- CORR 2009
  - Medial & lateral plateau slope

- ICC inter 0.77 and intra = 0.80
- **Medial plateau was 3.4° smaller on MRI vs xray**



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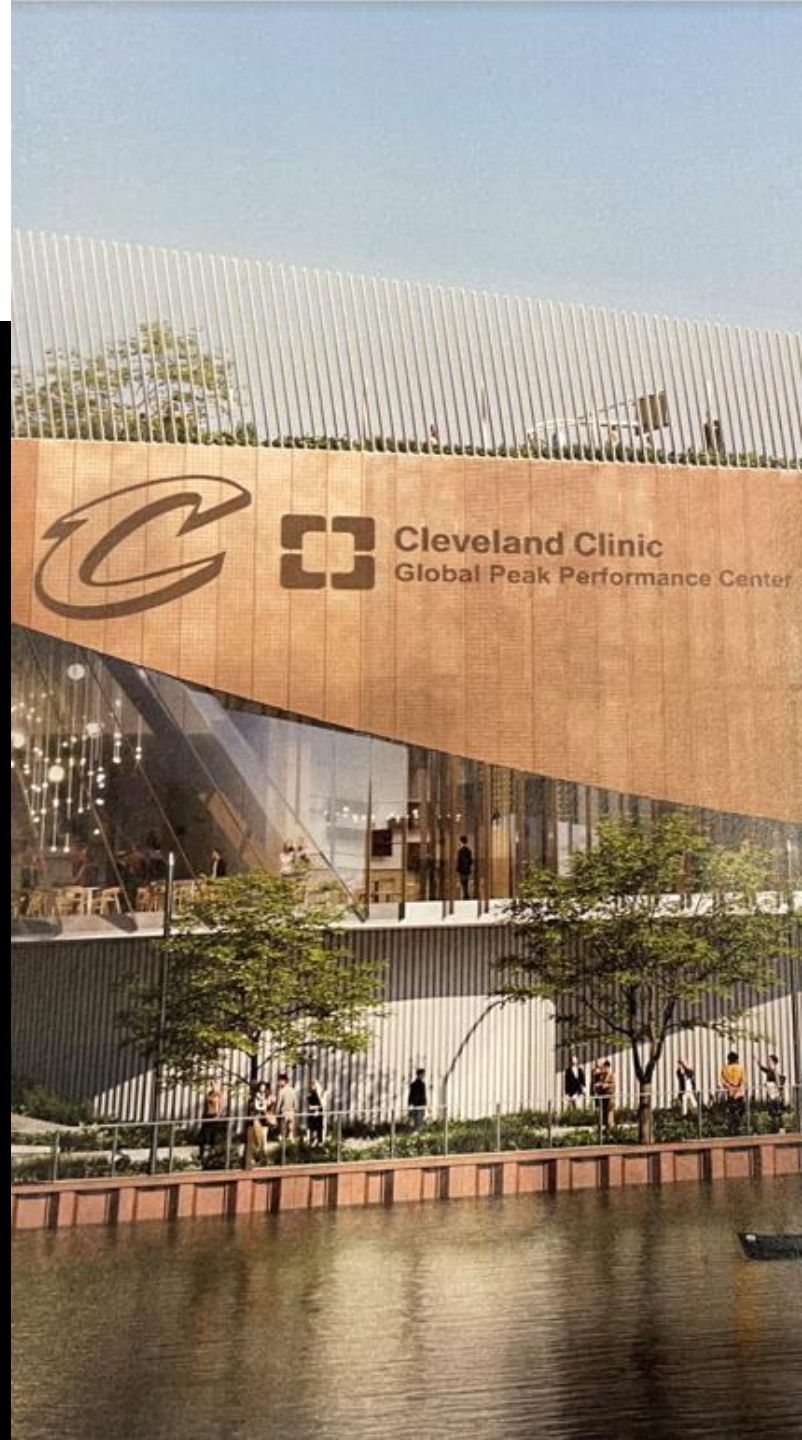
An increased posterior tibial slope is associated with a higher risk of graft failure following ACL reconstruction: a systematic review

LOE: 4

Zhongcheng Liu[1] · Jin Jiang[1] · Qiong Yi[1] · Yuanjun Teng[1] · Xuening Liu[1] · Jinwen He[1] · Kun Zhang[1] · Lifu Wang[1] · Fei Teng[1] · Bin Geng[1] · Yayi Xia[1] · Meng Wu[1]

- KSSTA 2022
  - 20 studies:
    - 12 measurement methods
  - Large heterogeneity in PTS values existed between different measurement methods



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Hypothesis and Aims

- **Hypothesis:** Increased PTS is NOT a predictor of graft failure in hamstring ACLR
- **Aim 1:** Identify predictive risk of ACL graft failure due to posterior tibial slope when controlling for known risk factors
- **Aim 2:** Identify predictive risk of any ipsilateral surgery including meniscus, cyclops etc.

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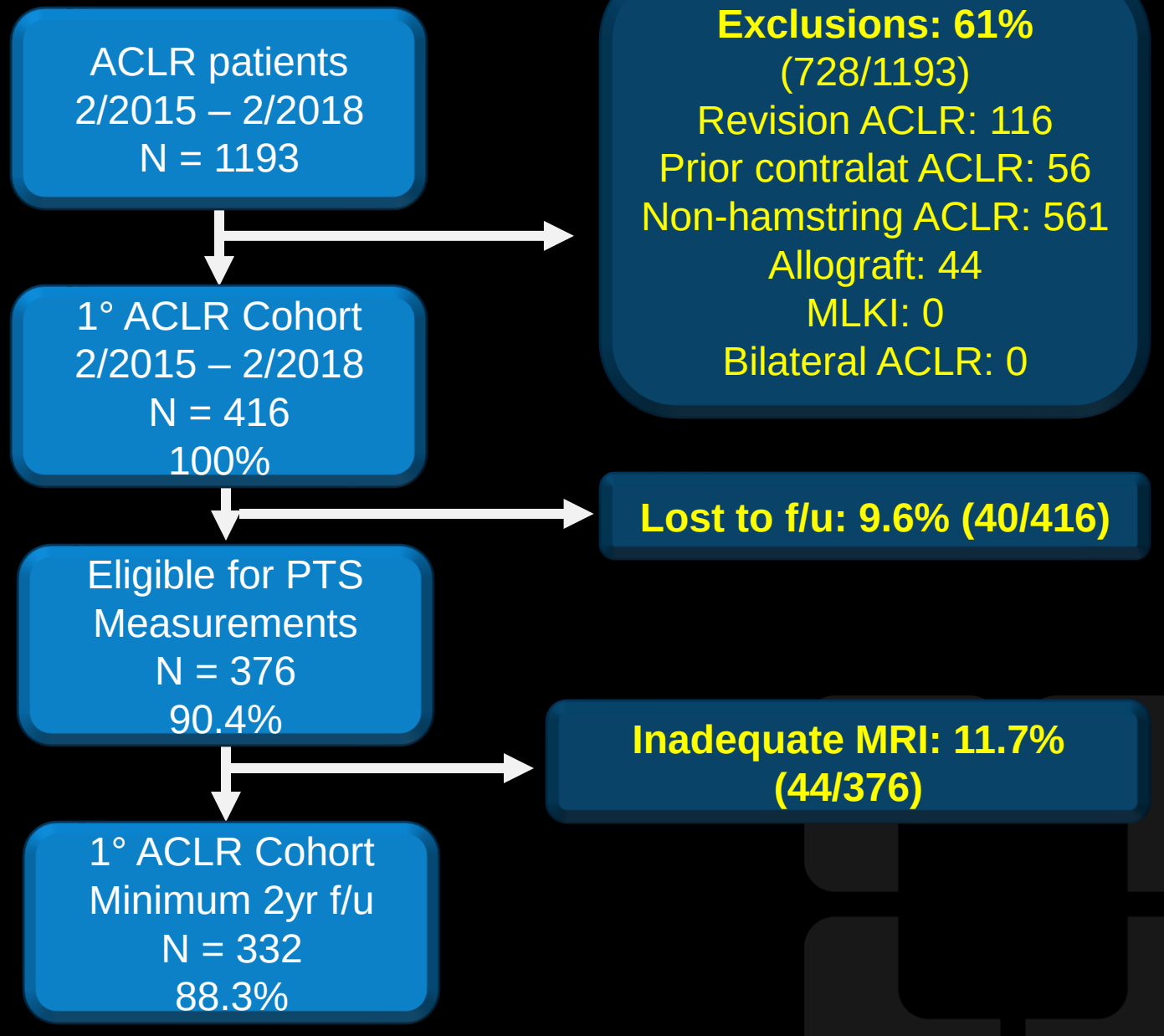
Methods

- Outcomes Measurement and Evaluation (OME) Tool
  - Prospective cohort
  - LOE 2
- Exclusions:
  - <2 year f/u
  - Prior contralateral ACLR
  - MLKI
  - Revision ACLR
- MRI's measured by 3 authors
- 90% F/U OME at 2 years



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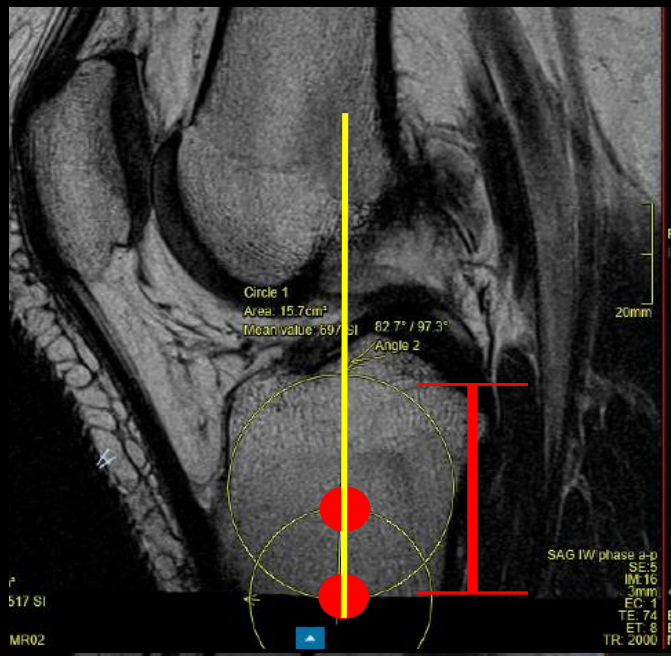
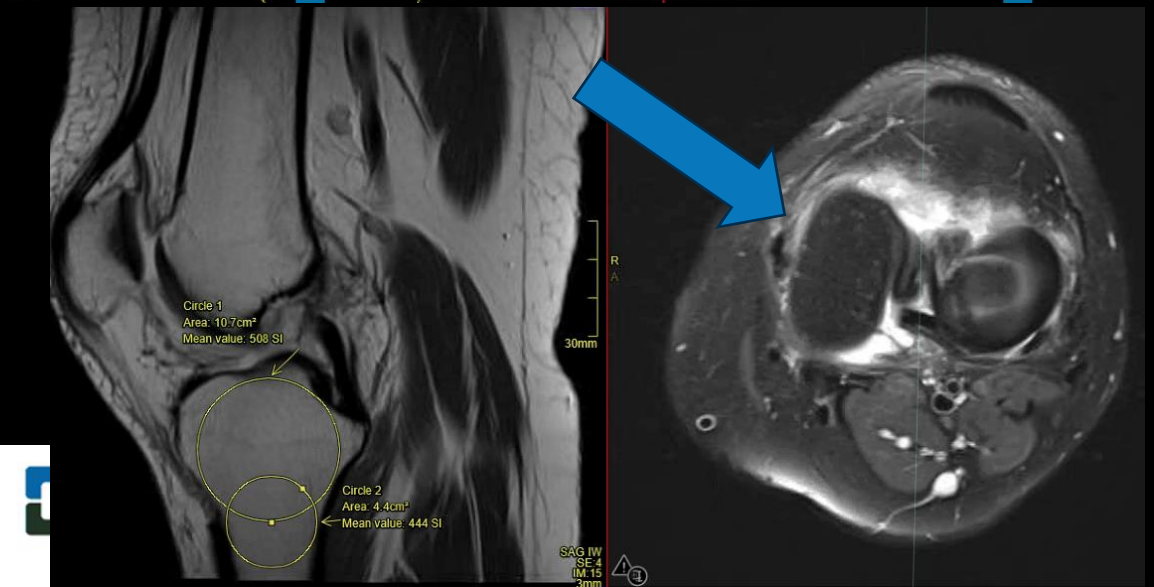
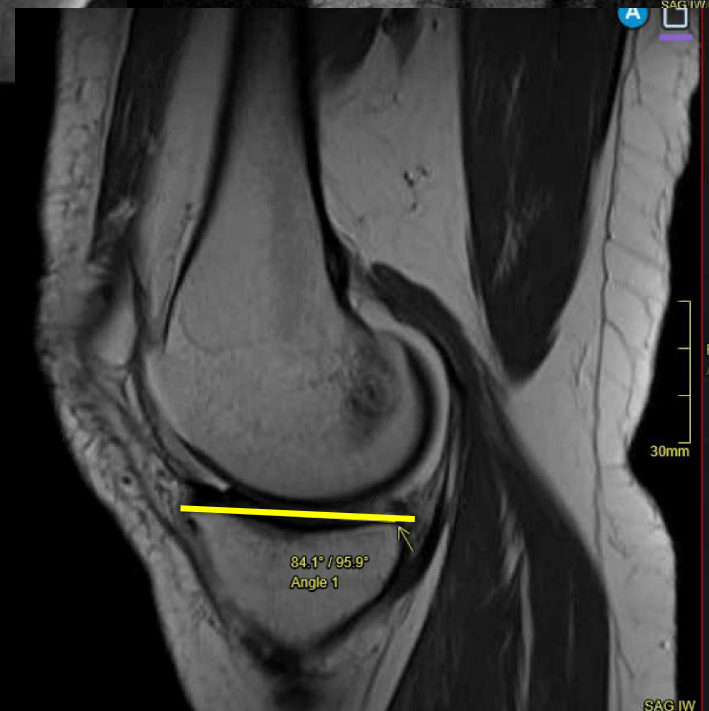
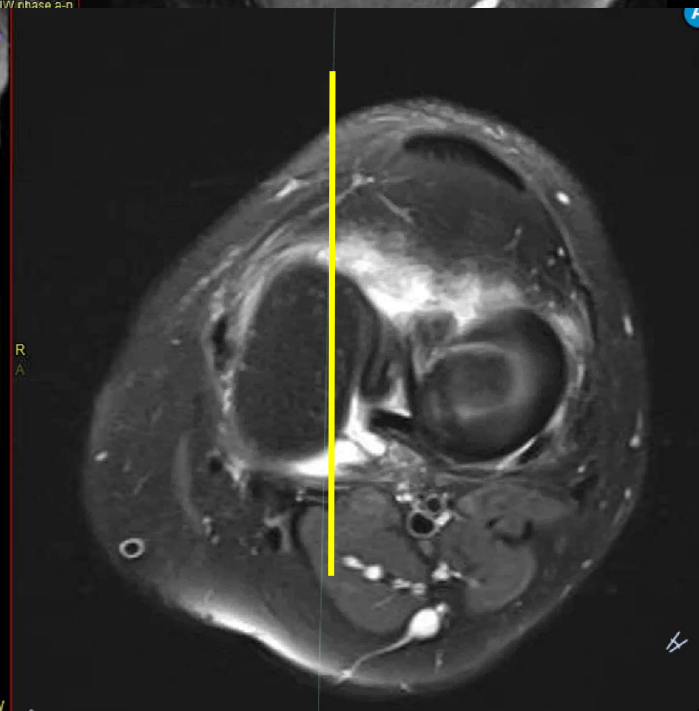
Methods: Measuring Slope in Clinic



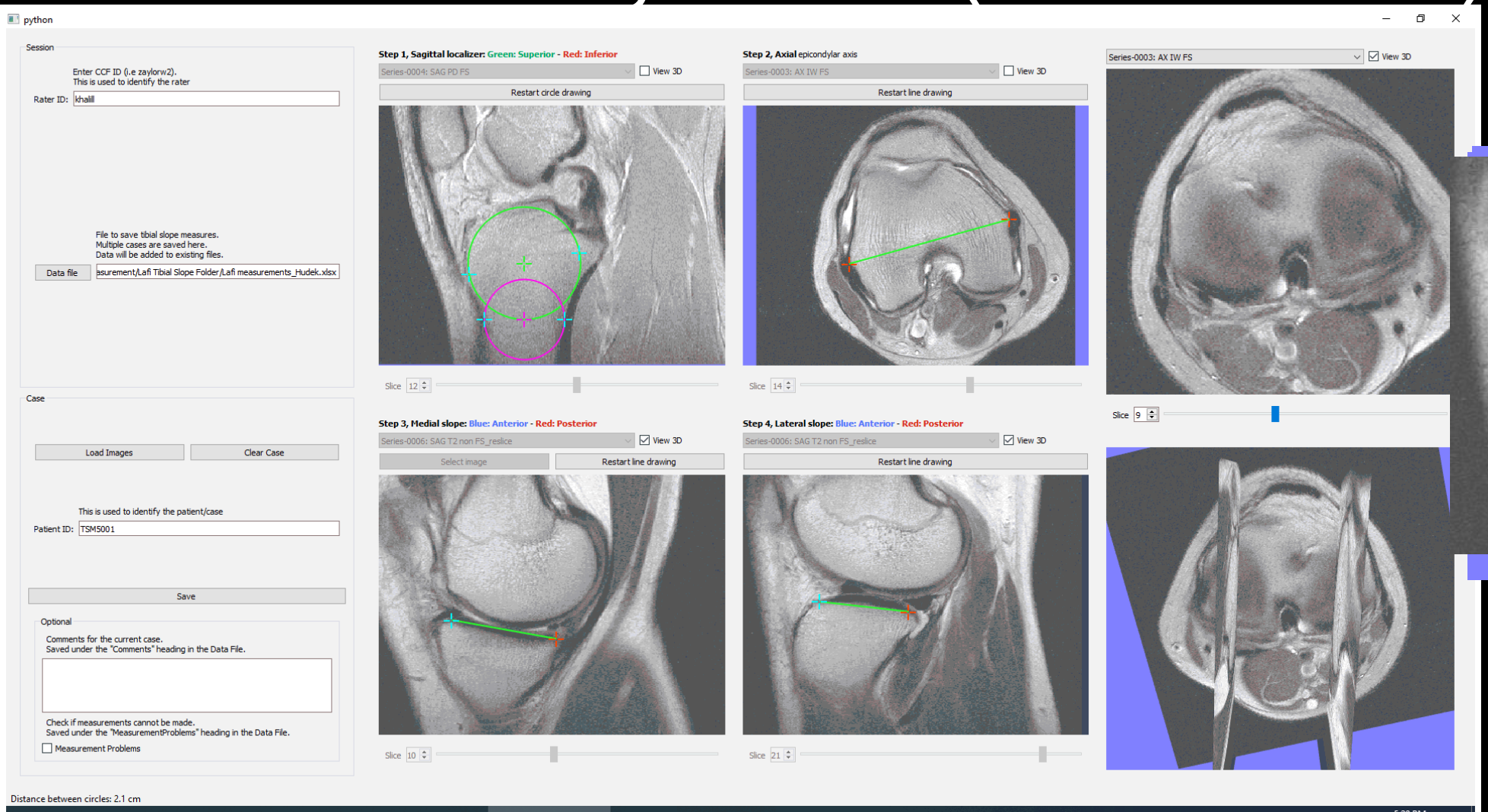






Methods: Software Development

- Dr. William Zaylor PhD (Dr. Mei Li lab)



Methods: Statistical Analysis

- Effect of PTS on risk of subsequent surgery or graft failure analyzed using multivariable linear regression modeling
- Controlled for:
  - Age
  - Sex
  - BMI
  - MARX activity score
- Two-year outcomes
  - Subsequent surgery to either knee

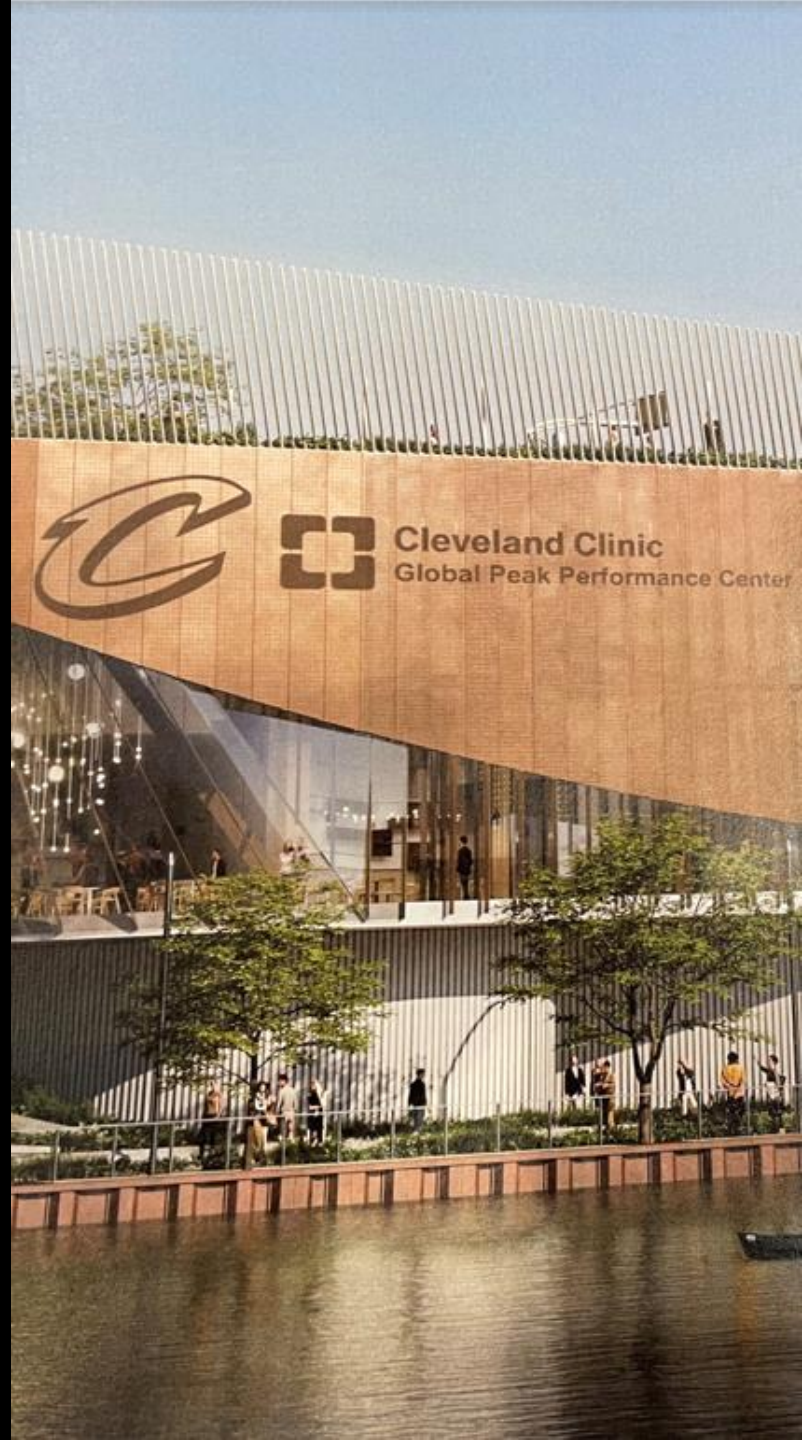


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Table 1 Patient Demographics

Variable	Level	All (n=376)	N
Age		**23.0 [17.0;35.0]**	**376**
Sex	M	**222 (59.0%)**	**376**
	F	**154 (41.0%)**	
BMI		**25.5 [22.7;28.5]**	**376**
Baseline MARX		**8.00 [0.00;12.0]**	**310**
Baseline MARX (categorical)	<12/Missing	**260 (69.1%)**	**376**
	>=12	**116 (30.9%)**	
Sport	Football/Soccer	**98 (26.1%)**	**376**
	Other	**278 (73.9%)**	
Medial Tibial Slope		**6.10 (3.09)**	**332**
Lateral Tibial Slope		**6.00 (3.03)**	**332**

Continuous variables presented as Median (IQR) or Mean (SD). Categorical variables presented as N (column %).

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Table 2 Outcomes

Variable	Level	All (n=376)	N
Strands		4.34 (0.94)	376
Strand (categorical)	2	27 (7.18%)	376
	3	2 (0.53%)	
	4	199 (52.9%)	
	5	115 (30.6%)	
Autograft Diameter		8.54 (0.74)	376
Ipsilateral Subsequent Surgery (All)		58 (15.4%)	376
Ipsilateral Surgery Type	Revision ACLR	27 (7.18%)	376
	Meniscus Repair	3 (0.80%)	376
	Meniscectomy	24 (6.38%)	376
	Lysis of Adhesions	4 (1.06%)	376
	Debridement of Cyclops Lesion	6 (1.60%)	376
	Articular Debridement/Chondroplasty	11 (2.93%)	376
	Other	15 (3.99%)	376
Days from surgery to subsequent ipsilateral surgery		672 (531)	58

Continuous variables presented as Median (IQR) or Mean (SD). Categorical variables presented as N (column %).

Table 3 Multivariable Model Ipsilateral ACLR

Predictors	Odds Ra… [95%CI]	P-value	Odds Ra… [95%CI]	P-value	Odds Ra… [95%CI]	P-value
Age (IQR Increase)	0.18 (0.06 – 0.53)	0.002	0.22 (0.08 – 0.65)	0.006	0.22 (0.08 – 0.65)	0.006
Sex (Female v Male)	0.66 (0.26 – 1.63)	0.363	0.92 (0.35 – 2.43)	0.867	0.91 (0.34 – 2.41)	0.849
Sports FB/Soc	0.78 (0.34 – 1.83)	0.574	0.59 (0.24 – 1.42)	0.238	0.59 (0.24 – 1.42)	0.235
Autograft Diameter	0.72 (0.39 – 1.34)	0.302	0.84 (0.45 – 1.59)	0.600	0.85 (0.45 – 1.60)	0.610
Medial Slope	-	-	0.96 (0.83 – 1.10)	0.547	-	-
Lateral Slope	-	-	-	-	0.97 (0.84 – 1.12)	0.663
R^2	0.115		0.105		0.104	
C-statistics	0.728		0.719		0.718	

Table 4 Multivariable Model: Any Ipsilateral Surgery

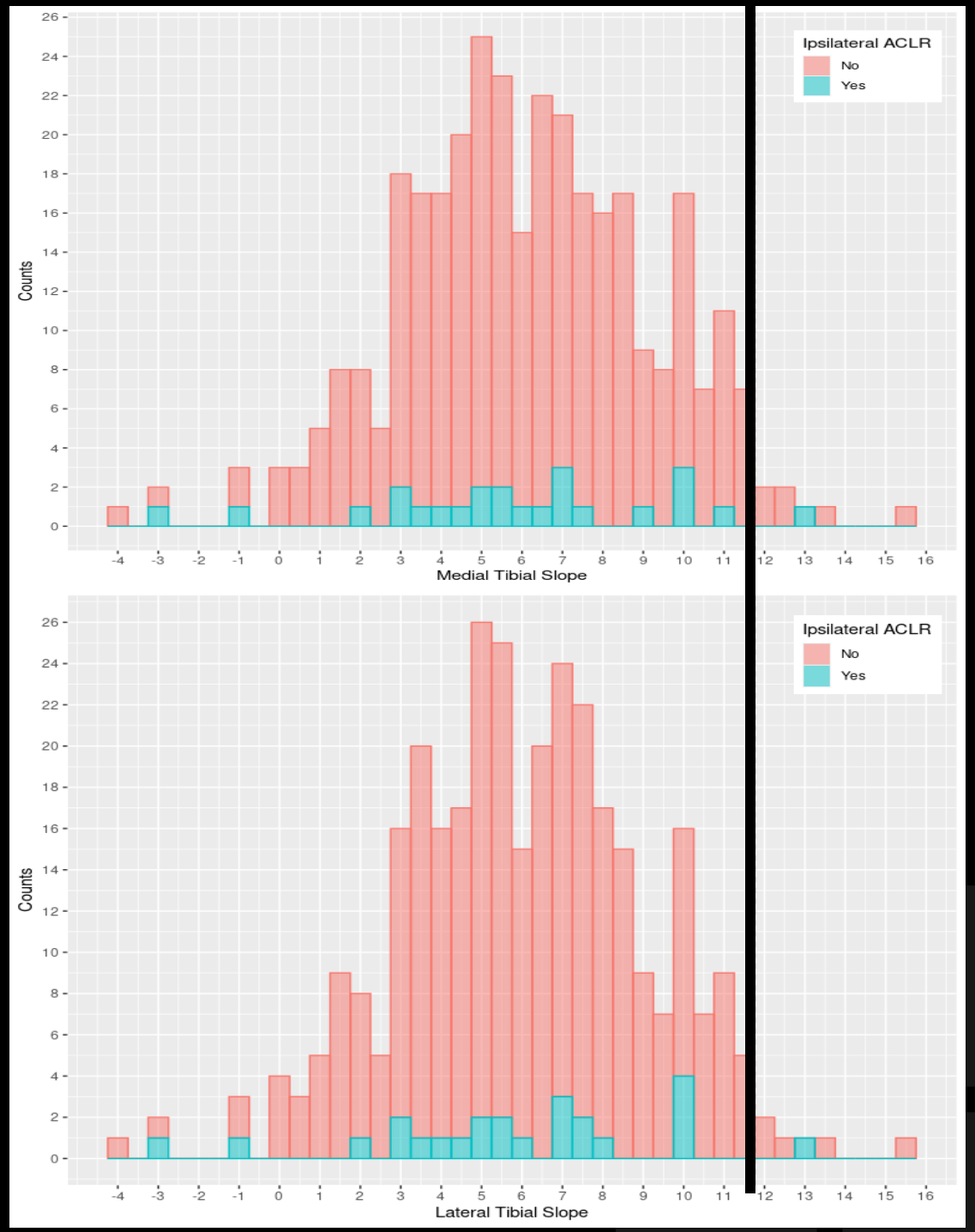
Predictors	Odds Ratio [95%CI]	P-value	Odds Ratio [95%CI]	P-value	Odds Ratio [95%CI]	P-value
Age (IQR Increase)	0.68 (0.39 – 1.19)	0.182	0.76 (0.43 – 1.34)	0.344	0.77 (0.44 – 1.35)	0.359
Sex (Female v Male)	0.80 (0.42 – 1.55)	0.513	0.82 (0.41 – 1.66)	0.589	0.83 (0.41 – 1.67)	0.594
BMI (IQR Increase)	0.81 (0.55 – 1.19)	0.278	0.76 (0.50 – 1.16)	0.207	0.76 (0.49 – 1.16)	0.205
Baseline MARX (+/-12)	2.47 (1.37 – 4.47)	0.003	2.07 (1.10 – 3.92)	0.025	2.09 (1.11 – 3.94)	0.023
Autograft Diameter	0.89 (0.57 – 1.39)	0.596	0.89 (0.56 – 1.43)	0.637	0.89 (0.56 – 1.43)	0.638
Medial Slope	-	-	0.96 (0.86 – 1.06)	0.421	-	-
Lateral Slope	-	-	-	-	0.96 (0.86 – 1.07)	0.436
C-statistics	0.671		0.658		0.657	

Histogram of Number ACLR

Over 95% of our Slopes <12 deg

MTP

LTP



Conclusions

- Predictors of graft failure:
  - Age
  - Activity level
- M/L Slopes >12° not predictive of HS ACLR failure
- Medial and lateral tibial slopes average 6 degrees (SD = 3 degrees)

Future Investigation

- Is PTS predictive of contralateral ACL injury?
- Long-term outcomes
- Radiographic slope measurements for patients with acceptable lateral clinical radiographs

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Thank You

- Lafi Khalil MD
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- Michael Dube
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- Matthew Anderson MD
- Mei Li PhD
- William Zaylor PhD
- Carl Winalski MD
- Chao Zhang
- Kurt Spindler MD

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