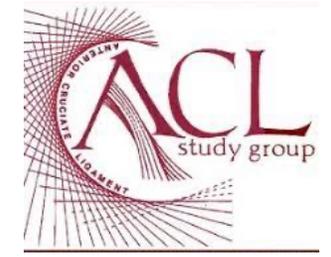




WBCT and ACL Reconstruction

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SANTI Study Group / ACL Study Group



Declaration of conflicts of interest

• Speaker

- Apsen
- Atlasmed (Reviscon)
- Conmed
- Curve Beam AI
- Geistlich
- Jonhson & Jonhson Med Tech
- Link Orthopaedics
- P&G Health
- Rigenera AMT
- Sintegra
- Smith Nephew
- VSY

Journals Editorial Board

- Arthroscopy Journal
- BMC Musculoskeletal disorders
- Knee Surgery Sports Traumatology and Arthroscopy
- Orthopaedic Journal of Sports Medicine
- Video Journal of Sports Medicine

Medical Societies

- **ACL Study Group** - Member-at-large / Program chair 2026
- **BS KNEE**
- **EPOREGEN**
- **ISAKOS** - Chair Young Professionals Task Force
- **SANTI STUDY GROUP**
- **SBCJ** - Member of the Scientific Support Committee
- **SBOT** - President of Education Projects Committee
- **SLARD** - Brazilian Representative in Board of directors
- **WBCT Society** - Knee Committee chair

Evidence-Based Research

Weight-bearing CT of joints can provide important new clinical information in musculoskeletal radiology. (AJR, Vol 200, Number 1)

The American Orthopedic Foot & Ankle Society recommends weight bearing imaging, when possible, to get the most accurate assessment of the foot & ankle. (AOFAS “Choosing Wisely” Guidelines)

- 150+ peer-reviewed published studies
- Established research org– International WBCT Society
- Incorporated into renowned university foot and ankle sections
 - Hospital for Special Surgery
 - Duke Orthopedics
 - University of Iowa Orthopedics
 - University of Pennsylvania
 - University of Colorado
 - University of Utah Orthopedics
 - Massachusetts General Hospital



International WBCT Society



Effects of peroneus longus harvesting for ACL reconstruction

PRIMARY

Evaluate functional results 2 years after reconstruction

Failure rate
IKDC
Lysholm

OBJECTIVES



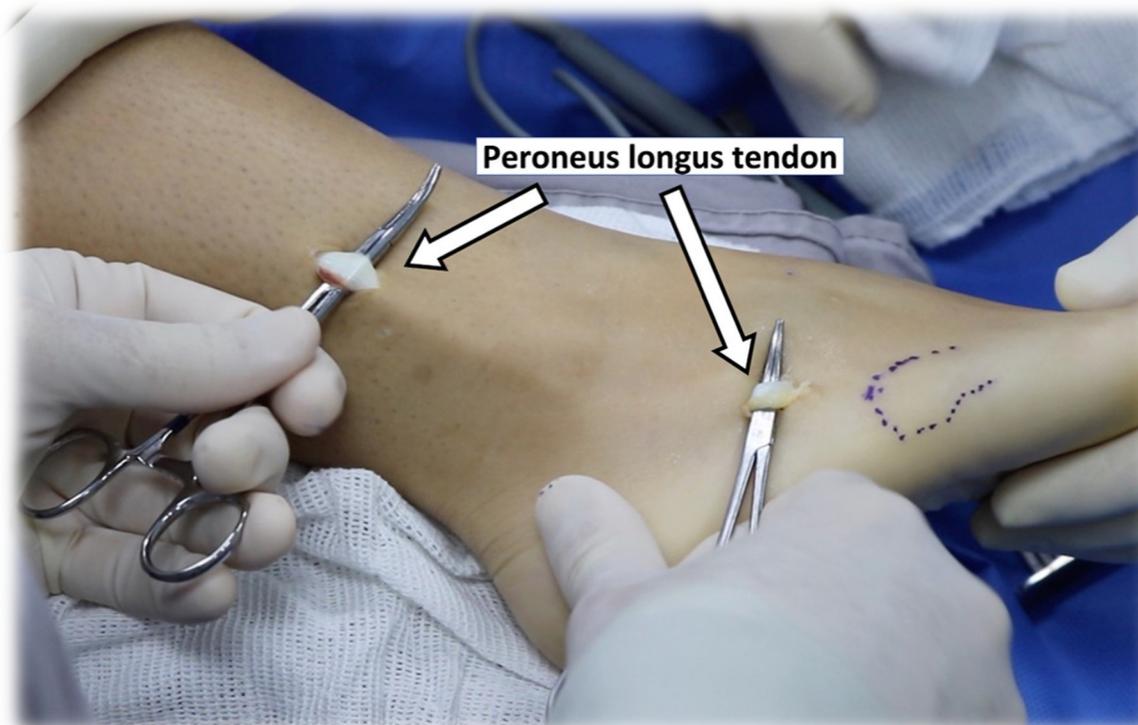
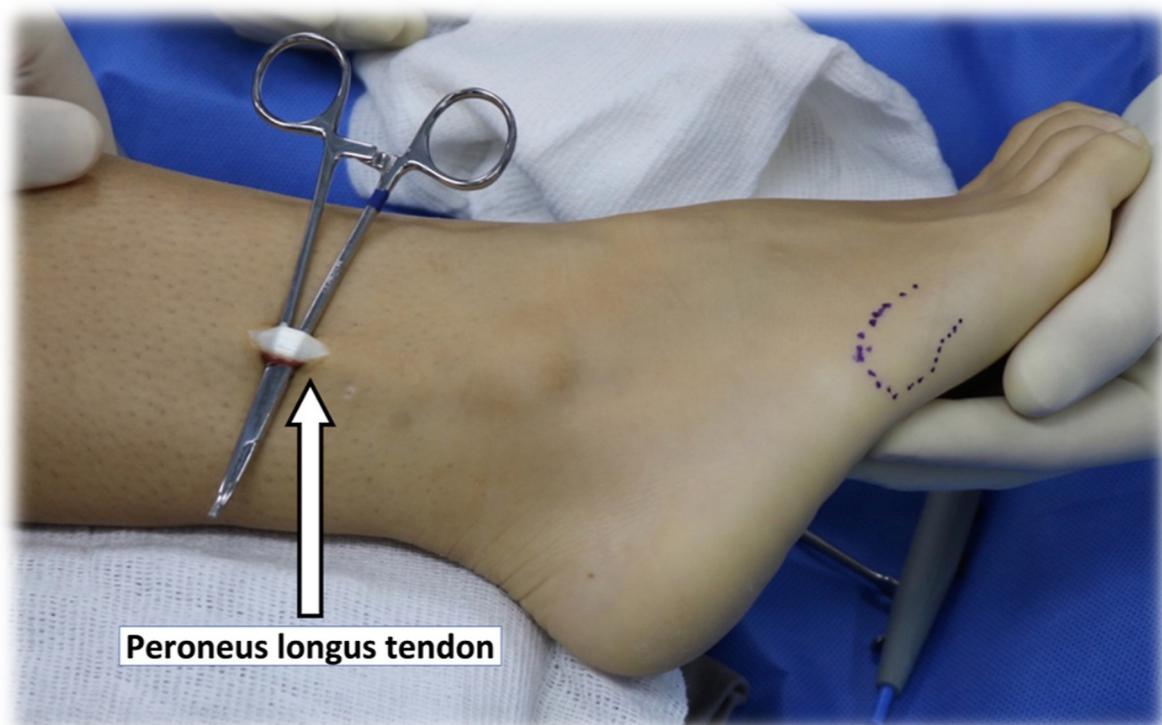
André Giardino MD
University of São Paulo

SECONDARY

Assess morbidity at the donor site



AOFAS
WBCT



Weight-bearing computed tomography in knee pathologies: current evidence and future perspectives

Weight-bearing computed tomography (WBCT) provides:

- Three-dimensional (3D)
- High-resolution imaging with patients in either a unipodal or bipodal stance
- Visualization of dynamic joint alterations that might be missed in conventional radiographs or in non-weight-bearing exams (CT or MRI)

Three-dimensional imaging acquisition with physiological load

Knee/ACL & WBCT - Ongoing projects

1. **Protocol description: Assessment of knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT) – published *Skeletal Rad***
2. **Evaluation of knee instability (ATT and FTR) using WBCT in patients with ACL tears: Quantifying anterior tibial translation and rotation in chronic ACL-deficient knees: a prospective, observational study using weight-bearing CT – published *Skelet Rad***
3. **Comparison of MR versus WBCT measurements of ATT and FTR in patients with chronic ACL tears – under review**
4. **Correlation between WBCT measurements of ATT and FTR and the orthopedic physical exam (Lachman and Pivot-shift) in patients with ACL tears (ongoing study)**
5. **Evaluation of tibial slope on WBCT in patients with ACL injury (under review)**
6. **Assessment of knee instability before and after ACL reconstruction using WBCT**

Assessment of knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT): Protocol description



Renata V Leao, MD

Skeletal Radiology
<https://doi.org/10.1007/s00256-024-04562-1>

TECHNICAL REPORT



Assessment of knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT): a novel protocol and preliminary results

Renata Vidal Leão¹ · Sandro Ricardo Benites Zelada² · Carlos Felipe Teixeira Lobo¹ ·
Andre Giardino Moreira da Silva² · Alexandre Leme Godoy-Santos³ · Riccardo Gomes Gobbi² ·
Paulo Victor Partezani Helito⁴ · Camilo Partezani Helito²

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Abstract

Objective To propose a protocol for assessing knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT).

Materials and methods We enrolled five patients with unilateral chronic ACL tears referred for WBCT. Bilateral images were obtained in four positions: bilateral knee extension, bilateral knee flexion, single-leg stance with knee flexion and external rotation, and single-leg stance with knee flexion and internal rotation. The radiation dose, time for protocol acquisition, and patients' tolerance of the procedure were recorded. A blinded senior radiologist assessed image quality and measured the anterior tibial translation (ATT) and femorotibial rotation (FTR) angle in the ACL-deficient and contralateral healthy knee.

Results All five patients were male, aged 23–30 years old. The protocol resulted in a 16.2 mGy radiation dose and a 15-min acquisition time. The procedure was well-tolerated, and patient positioning was uneventful, providing good-quality images. In all positions, the mean ATT and FTR were greater in ACL-deficient knees versus the healthy knee, with more pronounced differences observed in the bilateral knee flexion position. Mean lateral ATT in the flexion position was 9.1 ± 2.8 cm in the ACL-injured knees versus 4.0 ± 1.8 cm in non-injured knees, and mean FTR angle in the bilateral flexion position was $13.5^\circ \pm 7.7$ and $8.6^\circ \pm 4.6$ in the injured and non-injured knees, respectively.

Conclusion Our protocol quantitatively assesses knee instability with WBCT, measuring ATT and FTR in diverse knee positions. It employs reasonable radiation, is fast, well-tolerated, and yields high-quality images. Preliminary findings suggest ACL-deficient knees show elevated ATT and FTR, particularly in the 30° flexion position.

Assessment of knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT): Protocol description

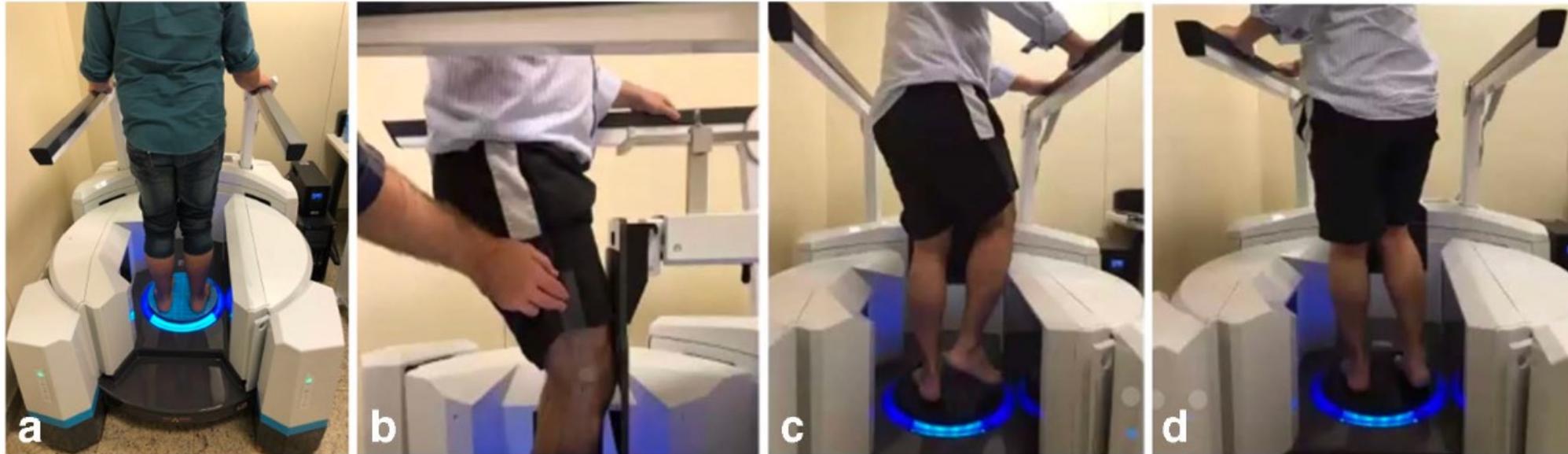
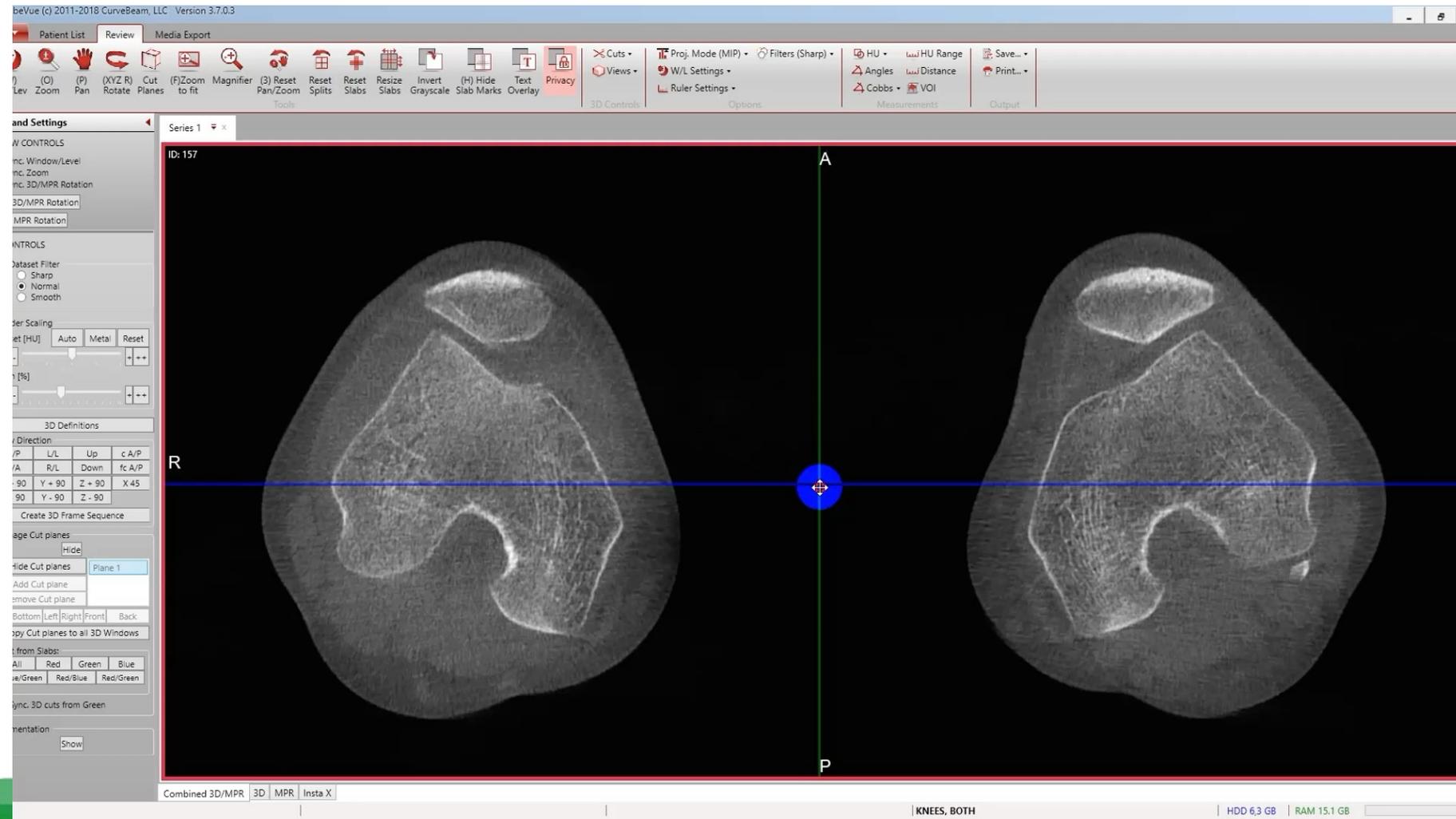


Fig. 1 Patient positioning in WBCT for evaluation of knee instability in ACL-deficient knees. **a** Bilateral extension. **b** Bilateral 30° flexion, using a goniometer to ensure adequate flexion degree. **c** Left single-

leg stance with knee flexion and internal rotation. **d** Left single-leg stance with knee flexion and external rotation

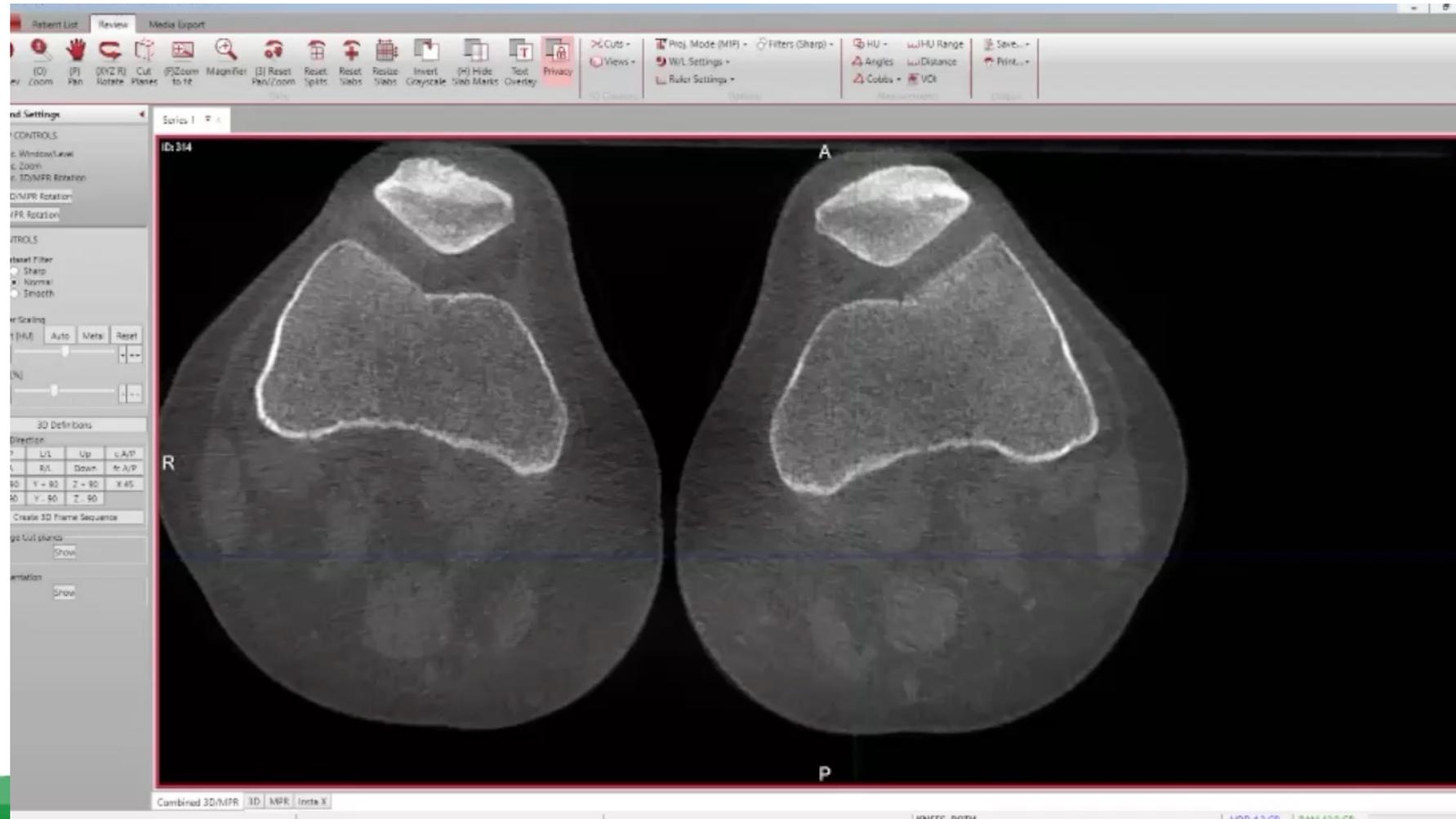
Assessment of knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT): Protocol description

- Tibial translation



Assessment of knee instability in ACL-injured knees using weight-bearing computed tomography (WBCT): Protocol description

- Femorotibial rotation





Quantifying anterior tibial translation and rotation in chronic ACL-deficient knees: a prospective, observational study using weight-bearing CT

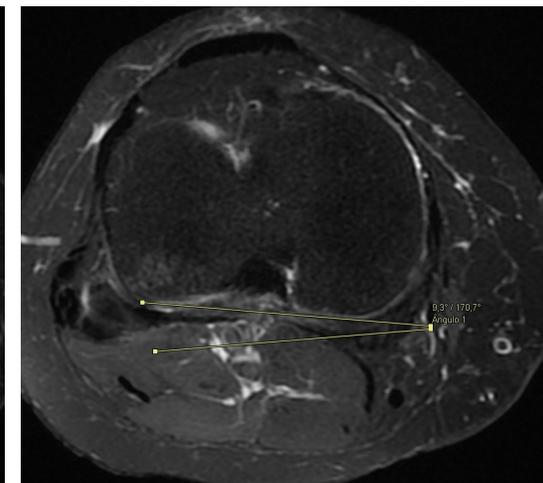
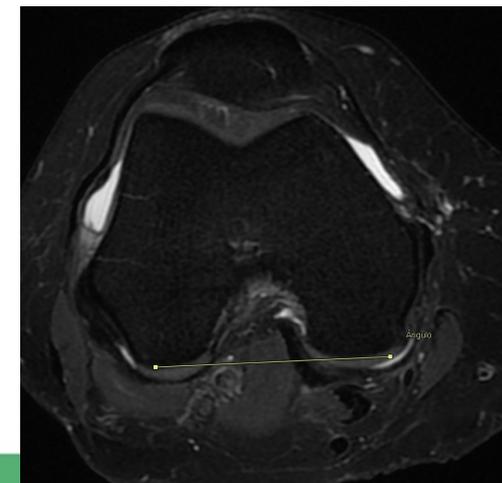
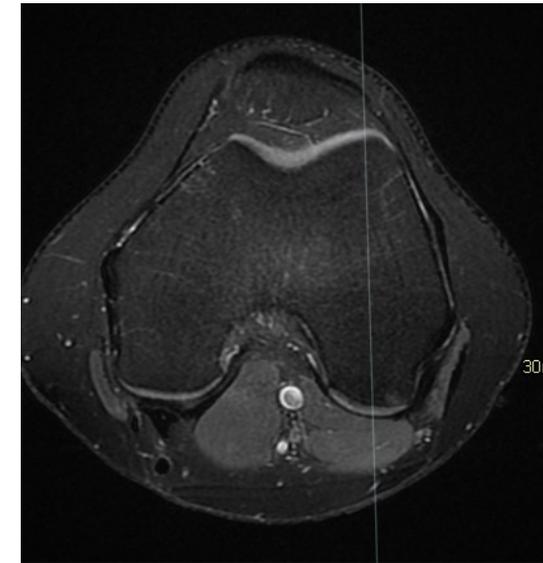
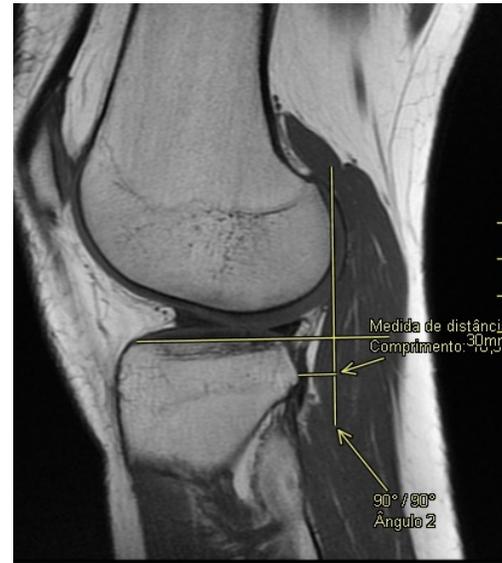
Sandro Ricardo Benites Zelada¹  · Renata Vidal Leão²  · Andre Giardino Moreira da Silva¹  ·
Carlos Felipe Teixeira Lobo³  · Alexandre Leme Godoy-Santos^{3,4}  · Paulo Victor Partezani Helito⁵  ·
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Comparative analysis of anterior tibial translation and femorotibial rotation on MRI versus weight-bearing CT in chronic anterior cruciate ligament tears: a prospective observational study

- Purpose: To compare ATT and FTR measurements obtained from WBCT and conventional MRI in patients with chronic ACL tears.
- WBCT may provide clinically relevant information on functional instability that complements MRI and may assist in preoperative assessment and surgical planning in patients with chronic ACL deficiency.



- MRI remains the reference standard for confirming ACL disruption and associated intra-articular pathology
- WBCT enables quantitative evaluation of compartment-specific anterior tibial translation and rotational instability under physiologic load
- WBCT may be particularly valuable in patients with:
 1. **Discordant clinical and MRI findings**
 2. **Suspected rotational instability**
 3. **Persistent symptoms**, where conventional supine MRI may underestimate functional instability
 4. **Standalone modality for follow-up**, allowing simultaneous assessment of load-dependent instability and osseous parameters such as tunnel positioning and bone consolidation



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The Knee

journal homepage: www.elsevier.com/locate/thekne



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An isolated extra-articular procedure can be indicated for patients with minor instabilities and intact graft after anterior cruciate ligament reconstruction



Camilo Partezani Helito ^{a,}, Andre Giardino Moreira da Silva ^{a,*}, Matt Daggett ^c, Sergio Marinho de Gusmao Canuto ^d, Carlo Leekninh Paione ^e, Hernan Galan ^f, Riccardo Cristiani ^{g,h}



Table 3

Pre- and postoperative physical exam findings and patient-reported outcome measures of patients who underwent an isolated lateral extra-articular procedure to address residual instability after ACL reconstruction.

	Pre-operative	Postoperative	<i>P</i>
KT-1000	3.0 ± 0.7	2.0 ± 0.4	0.00016
Positive pivot-shift	20/20 (100%)	6/20 (30%)	< 0.0001
IKDC	74.4 ± 11.8	87.6 ± 5.6	0.087
PASS IKDC	9/20 (45%)	19/20 (95%)	0.0012
Lysholm	81.1 ± 7.3	91.2 ± 5.7	0.0001
GPE		4.0 ± 0.7	

GPE, Global Perceived Effect; IKDC, International Knee Documentation Committee; PASS, Patient Acceptable Symptom State.

> [Knee Surg Sports Traumatol Arthrosc.](#) 2022 Jun;30(6):1958-1966.

doi: 10.1007/s00167-021-06854-8. Epub 2022 Jan 29.



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Lateral extraarticular tenodesis improves stability in non-anatomic ACL reconstructed knees: in vivo kinematic analysis

Simone Perelli ^{1 2}, R
Gonzalo Rojas-Castil

> [Knee Surg Sports Traumatol Arthrosc.](#) 2023 Aug;31(8):3212-3220.

doi: 10.1007/s00167-023-07344-9. Epub 2023 Feb 22.

Isolated lateral extra-articular tenodesis in ACL-deficient knees: in vivo knee kinematics and clinical outcomes

Simone Perelli ^{1 2}, Pablo Eduardo Celber ^{3 4}, Rodolfo Morales Avila ^{5 6}, Sergio Rojas ⁷

Raul Torres-Claramunt ^{8 3}, Jc > [J Knee Surg.](#) 2025 Mar;38(4):207-215. doi: 10.1055/a-2481-8771. Epub 2024 Nov 22.

Isolated Lateral Extra-Articular Tenodesis for Ongoing Instability Following Anterior Cruciate Ligament (ACL) Reconstruction with an Intact Graft is Effective and Has Low Surgical Morbidity

Peter S E Davies ^{1 2}, Cameron Muirhead ^{1 2}, Alistair I W Mayne ^{1 2}, Jay R Ebert ^{1 3 4},
Peter K Edwards ^{1 5}, Ashley Simpson ⁶, Andy Williams ⁷, Peter D'Alessandro ^{1 2 8}

- MRI remains the reference standard for confirming ACL disruption and associated intra-articular pathology
- WBCT enables quantitative evaluation of compartment-specific anterior tibial translation and rotational instability under physiologic load
- WBCT may be particularly valuable in patients with:
 1. **Discordant clinical and MRI findings**
 2. **Suspected rotational instability**
 3. **Persistent symptoms**, where conventional supine MRI may underestimate functional instability
 4. **Standalone modality for follow-up**, allowing simultaneous assessment of load-dependent instability and osseous parameters such as tunnel positioning and bone consolidation

WBCT less expensive and faster than MRI

Advantages of WBCT



Quick Acquisition

Reduced scanning time compared to MRI, improving clinical workflow and patient comfort.



Physiological load examination of the knee

It allows for full-length scanning under physiological load conditions, replicating real-life situations.



Cost-effectiveness

Lower operating costs compared to conventional magnetic resonance imaging.



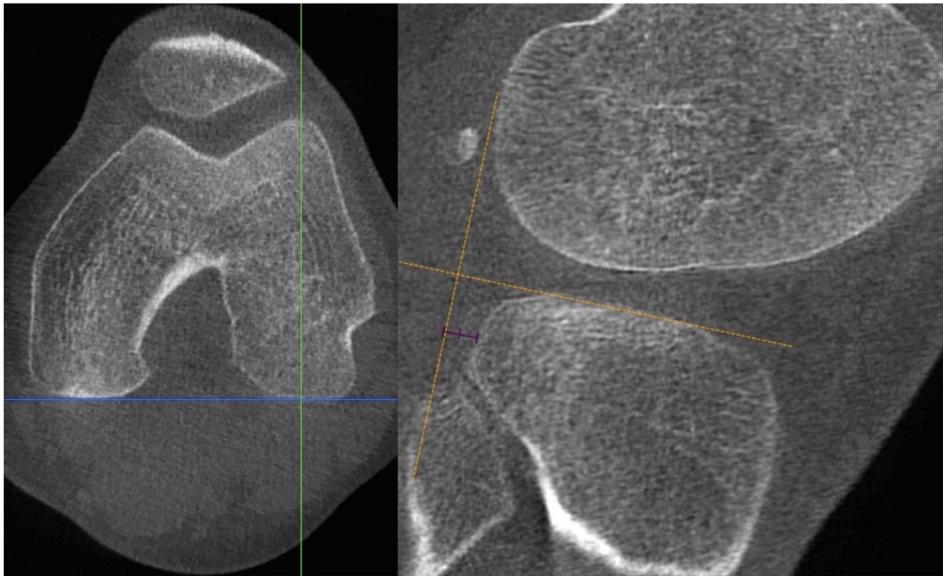
Post-Operative Evaluation

It allows for simultaneous evaluation of postoperative parameters such as tunnel positioning and bone consolidation.

Measurements

Anterior tibial translation

Measure separately in the medial and lateral compartments



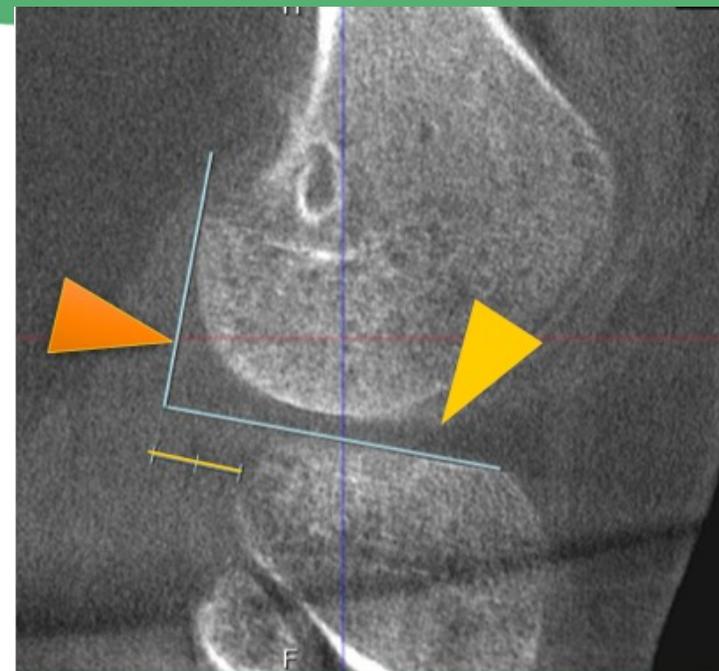
WBCT

Difference in ATT

after ACL recon



IOWA



- 3 months

Delta ATT	Quad	BTB	Hs
L Flexion	-0.26	1.9	1.02

- 1 year

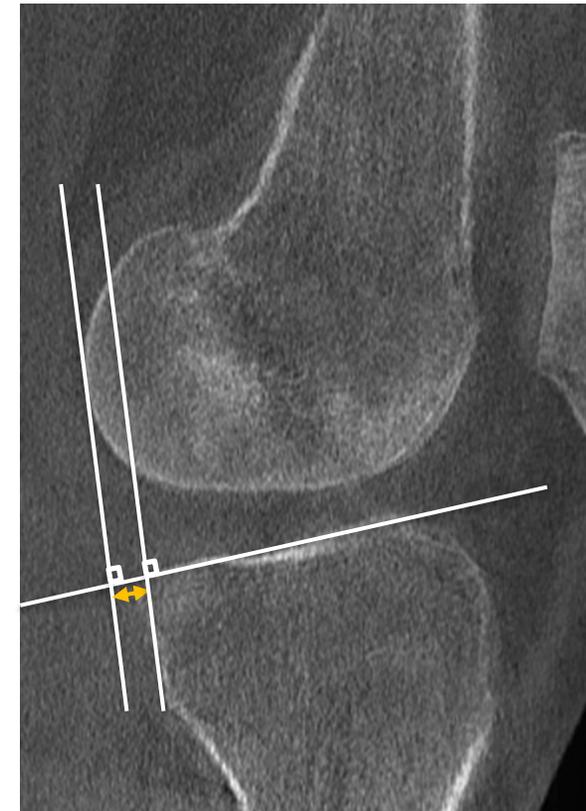
Delta ATT	Quad	BTB	Hs
L Flexion	0.56	-0.72	-3.26

- **Objective characterization of instability –
Lachmeter (less precise than WBCT)**



Correlation between WBCT measurements of ATT and FTR and the orthopedic physical exam (Lachman and Pivot-shift) in patients with ACL tears

- Purpose: To correlate the measurements of ATT and FTR obtained from WBCT with preoperative orthopedic clinical examination findings (Pivot-shift and Lachman tests).
- Does the WBCT allow for a reliable and objective assessment of knee instability?
- Is there a correlation between the instability assessed in WBCT and standard clinical instability assessment tests?



Problem...

- Radiation (12.6 μSv)
- Lower radiation exposure compared with conventional multidetector CT (MDCT) (27–48 μSv)
- Higher than that of standard plain radiographs (1.2–1.8 μSv)

Evaluation of tibial slope on WBCT in patients with ACL injury

- Objective: To measure the anatomical posterior medial and lateral tibial slope in knees with complete ACL rupture on WBCT and correlate the obtained measurements with the degree of ATT in 30-degree flexion images.
- Secondary Objective: To compare the slope values obtained in WBCT of patients with complete ACL ruptures with the slope measurements of contralateral knees with intact ACL.

Lateral Slope - WBCT

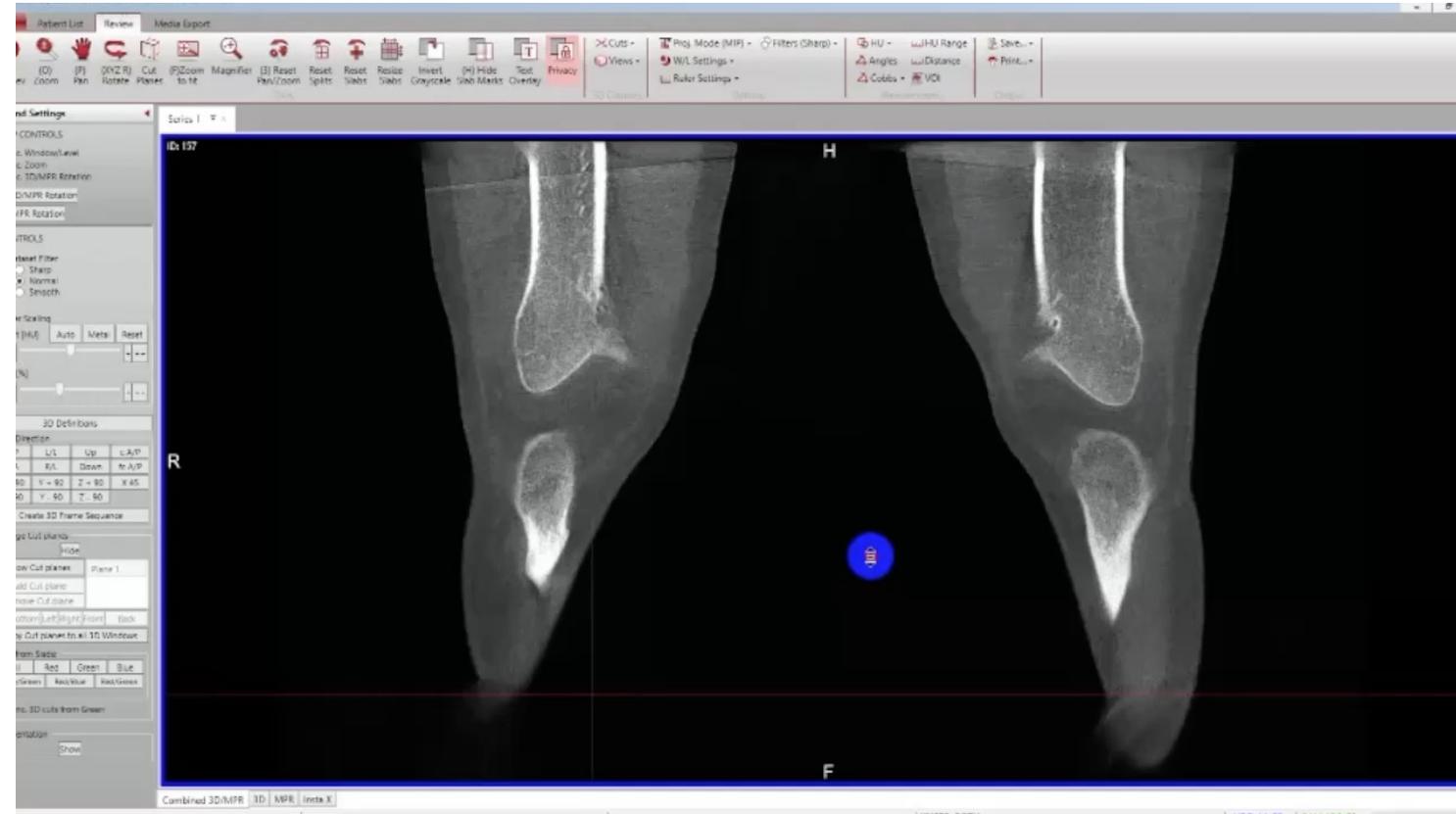


Medial Slope - WBCT



Evaluation of tibial slope on WBCT in patients with ACL injury

- Objective: To measure the anatomical posterior medial and lateral tibial slope in knees with complete ACL rupture on WBCT and correlate the obtained measurements with the degree of ATT in 30-degree flexion images.
- Secondary Objective: To compare the slope values obtained in WBCT of patients with complete ACL ruptures with the slope measurements of contralateral knees with intact ACL.

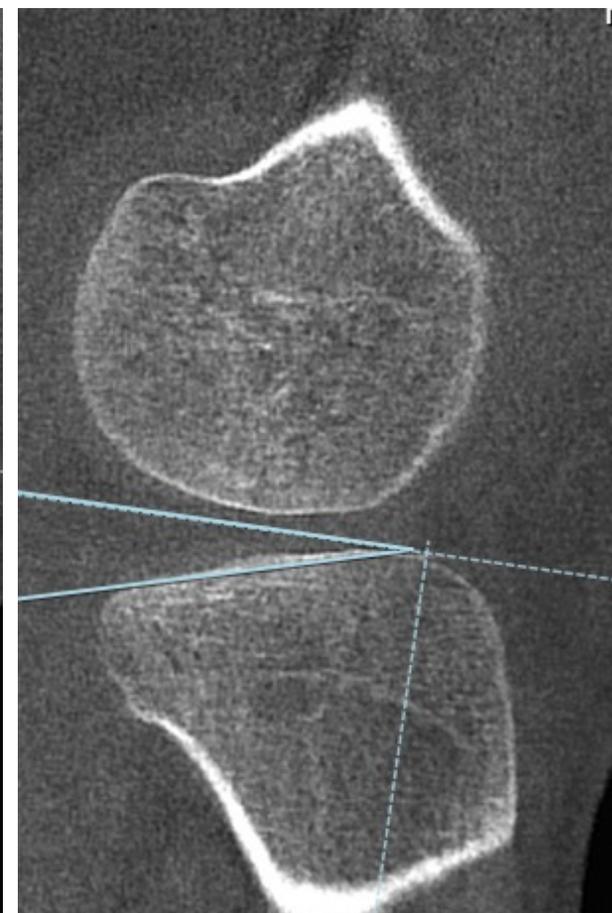
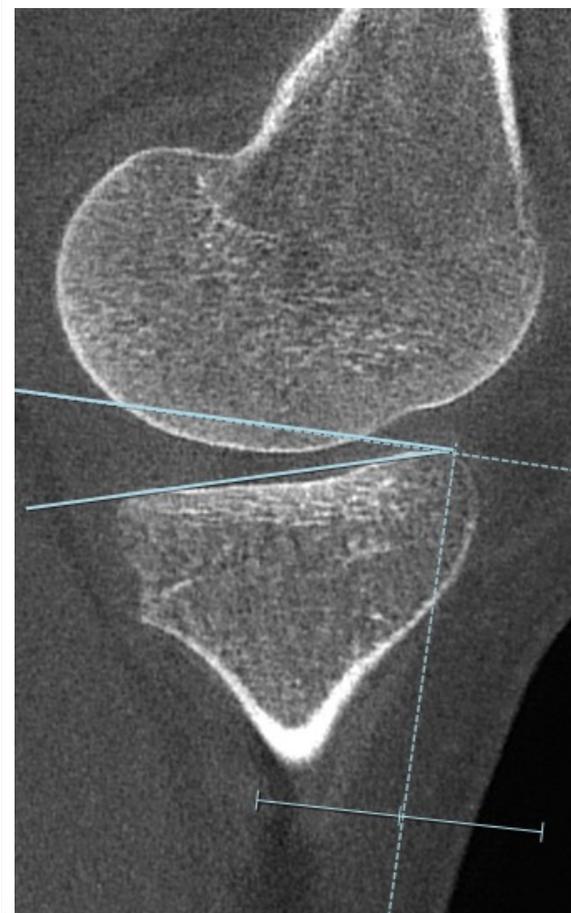


Posterior tibial slope



Medial

Lateral





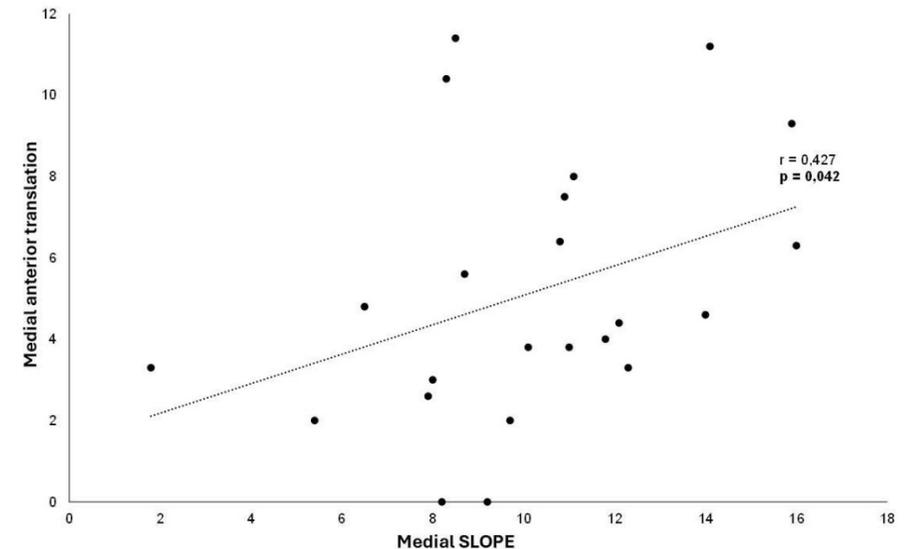
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**At least 10cm of the
tibia are needed for an
adequate measurment**

Steeper Medial Tibial Slope Correlates with Increased Sagittal Knee Instability in Chronic ACL Injury: A Pilot Study Using Weightbearing CT

- Direct correlation between the medial and lateral slopes ($r = 0.528$, $p = 0.010$)
- Direct correlation between the medial slope and medial anterior tibial translation ($r = 0.427$, $p = 0.042$), indicating that greater medial slope values were associated with greater medial anterior translation.



Future perspectives

- Artificial intelligence and machine learning algorithms may facilitate automated three-dimensional measurements
- WBCT datasets also hold promise for 3D printing applications
- Integration of WBCT with computer-assisted surgical navigation and robotic systems may enable more accurate, functionally informed alignment strategies in procedures such as osteotomies

Take home message

- **Think of WBCT as an easily accessible 3D technology**
- **It is a quick exam with the potential to deliver a lot of data**
- **Protocols for assessing knee instability already established**
- **Great alternative for accurate measurement of the tibial slope and associated anterior translation**
- **Good option for post-op follow up**
- **Negative points: radiation, so far there is still a lack of standardized acquisition and measurement protocols in most of knee pathologies**



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Muito Obrigado!
Thank you!
Gracias!

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