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# Multi-Center Evaluation of Knee Kinematics during different Activities for Anatomic Total Knee Design

Verstraete M, Van Onsem S, **Zambianchi F**, Lombardi V,  
Van der Straeten C, Victor J, Catani F.

No Conflicts of Interests to Disclose

2nd World Arthroplasty Congress  
Rome – April 19-21



# Introduction

## First Generation Bi-Cruciate Substituting TKA (2005) - Design

- Restore native knee kinematics
- Anatomic joint line (asymmetric polyethylene insert, 3°varus)
- Inherent screw-home mechanism to favor femoral internal rotation in full extension

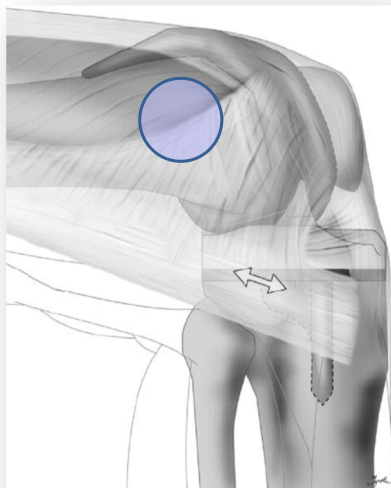
Victor J., Bellemans J. Clin Orthop Rel Res, 2006  
Komistek RD. et al. Clin Orthop Rel Res, 2003



# Introduction

## First Generation Bi-Cruciate Substituting TKA (2005) - Complications

- Increased incidence of ilio-tibial band (ITB) friction syndrome
- Episodes of knee dislocation
- Mechanical stress and fibrous metaplasia on the posterior capsule for excessive posterior femoral roll-back

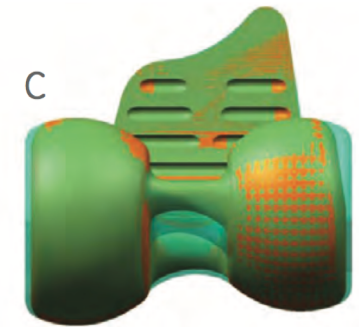
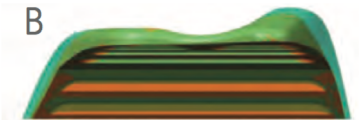
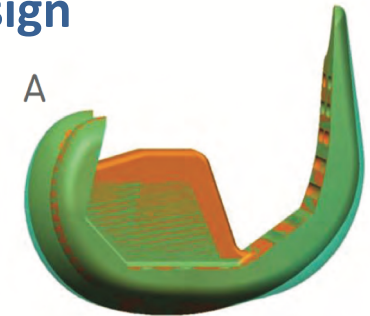
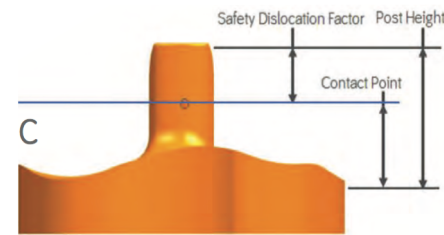


- 8% Lateral Parapatellar Release
- 4% Antero-lateral knee pain, conservative treatment
- 1.5% Persistent pain at the ilio-tibial tract
- 3% Post-operative stiffness treated with manipulation under anesthesia

# Introduction

## Second Generation Bi-Cruciate Substituting TKA (2013) - Design

- Taller box walls
- Thickness of the anterior flange: reduced of 1-2 mm to decrease tension on the ITB and ITPB
- Width: 2-3 mm decreased to limit implant overhang
- Superior cam position to decrease femoral rollback, increase femoral external rotation, lower the point of tibial post contact in deep flexion
- Increased height of the post and anterior placement



# Introduction

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**The Journal of Arthroplasty**

journal homepage: [www.arthroplastyjournal.org](http://www.arthroplastyjournal.org)

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Basic Science

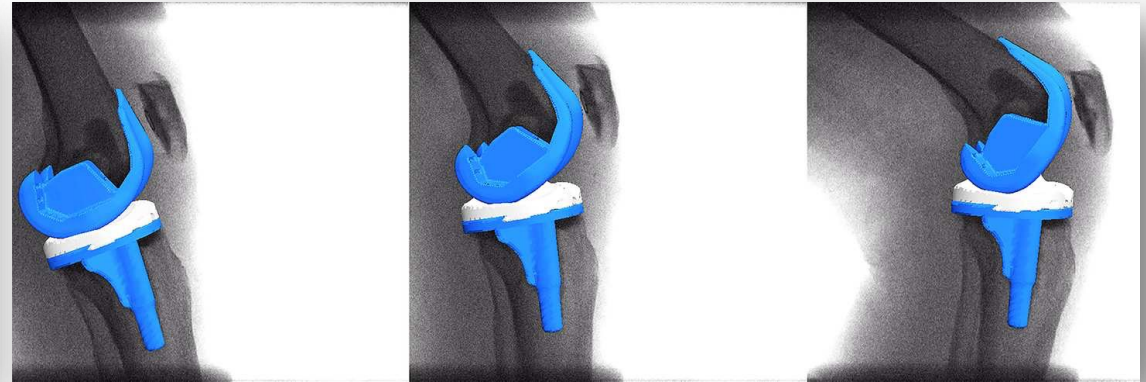
**In Vivo Kinematic Comparison of a Bicruciate Stabilized Total Knee Arthroplasty and the Normal Knee Using Fluoroscopy**

Trevor F. Grieco, MS<sup>a,\*</sup>, Adrija Sharma, PhD<sup>a</sup>, Garrett M. Dessinger, BS<sup>a</sup>, Harold E. Cates, MD<sup>b</sup>, Richard D. Komistek, PhD<sup>a</sup>

<sup>a</sup> Department of Mechanical, Aerospace, and Biomedical Engineering, Center for Musculoskeletal Research, University of Tennessee, Knoxville, Knoxville, Tennessee

<sup>b</sup> Tennessee Orthopaedic Clinics, Knoxville, Tennessee

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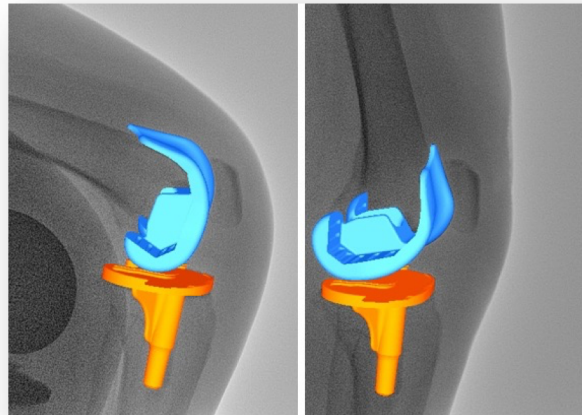
- Similar kinematic patterns from 0-30° and beyond 90° of knee flexion
- Lack of screw-home mechanism in BCS design compared to native knee (ACL resection )
- Post-cam mechanism replicates the role of the cruciates for antero-posterior displacement, but not for axial rotation
- In mid flexion (30-60° flexion) cruciates function can not be maintained

# Aim of the study

## In Vivo Kinematics of the Journey II Bi-Cruciate Stabilized Knee System: InVivo Fluoroscopic Analysis during Activities of Daily Living

- **Study Design:** Multicenter, prospective, post-market study
- **Primary Objective:** evaluate the kinematic behavior of a bi-cruciate substituting total knee system

Do we need «normal knee» kinematics to get back to optimal function and pain free joint?



# Materials and Methods

- Two Centers:



Università di Modena e Reggio-Emilia, Italy: 10 patients



Universiteit Gent, Belgium: 10 patients

- Journey II BCS Total Knee System implanted in all cases
- Examination time point: mean 9.3 months post-operatively (min. 3 - max. 13 months)
- Examined motions

Univerisità di Modena e Reggio-Emilia:

- Open Chain Flexion-Extension (FE)
- Closed Chain Stair Climbing (SC)
- Closed Chain Chair Rising (CH)

Universiteit Gent:

- Open Chain Flexion-Extension (FE)
- Closed Chain Squatting (SQ)
- Closed Chain Rising and Sitting (CH)

- Iterative “shape matching” technique of 3D prosthetic CAD models overlaid on 2D video-fluoroscopy images





# Materials and Methods

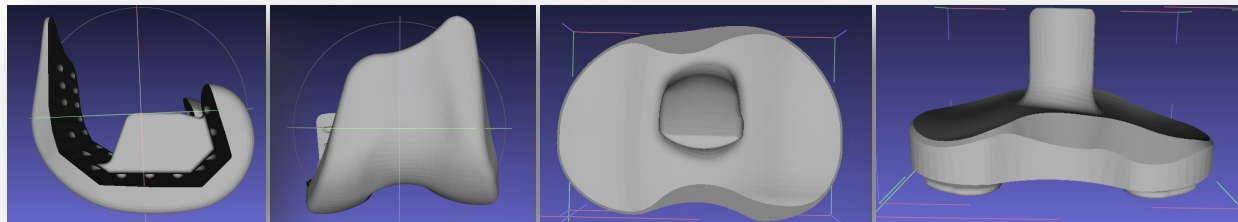
## Kinematic Analysis

### Femoral

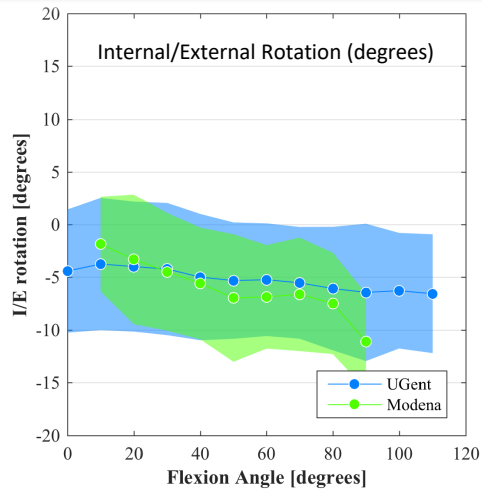
- Center of condyles for medial and lateral flexion facets

### Tibial

- ML dimension:  
centers defined at  $1/4$  and  $3/4$  of ML tibial implant width
- AP dimension:  
0 = most posterior point of tibial insert  
1 = most anterior point of tibial insert  
equal for medial and lateral compartment, regardless asymmetry in implant geometry

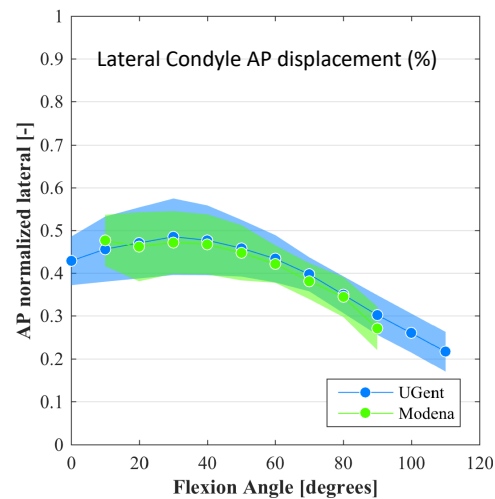
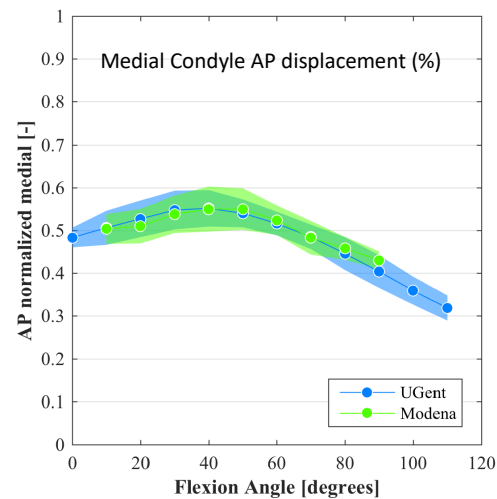


# Results: Open Chain – Flexion/Extension



## Axial Rotation

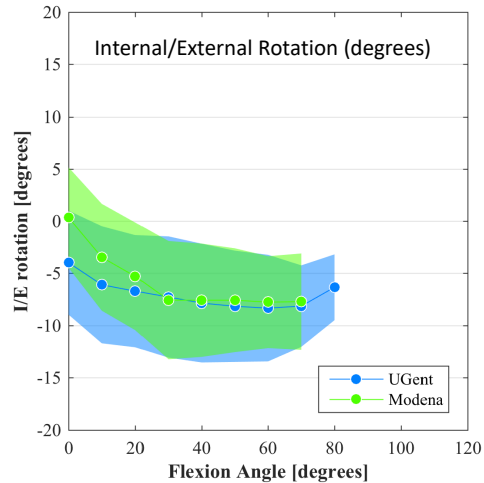
- Progressive moderate external rotation of the femoral component relative to the tibia with flexion
- Wide Standard Deviations
- No significant differences between the two centers



## AP Medial / Lateral Positioning

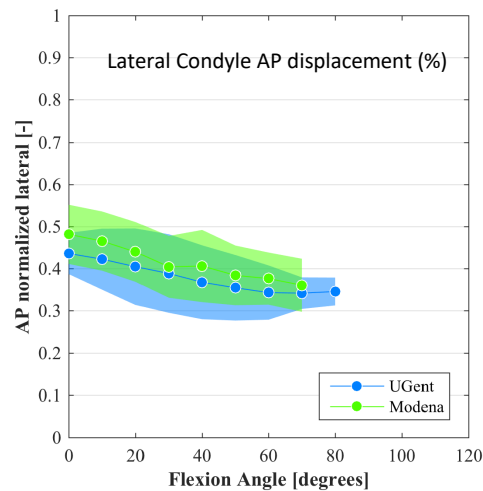
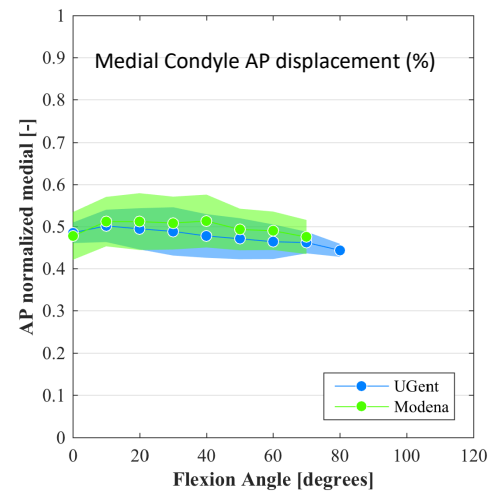
- Progressive posterior translation of the condyles with flexion
- Slight medial condyle anterior translation between 0-50°
- Bigger lateral condyle displacement
- No statistically significant differences between the two centers

# Results: Close Chain – Chair Rising



## Axial Rotation

- Significant progressive external rotation of the femoral component relative to the tibia with flexion
- No significant differences between the two centers



## AP Medial / Lateral Positioning

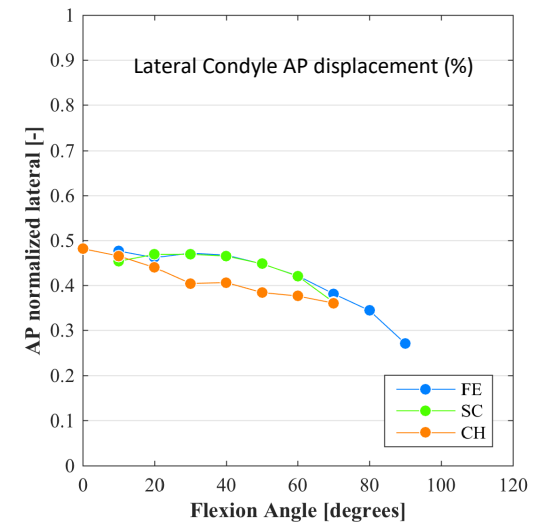
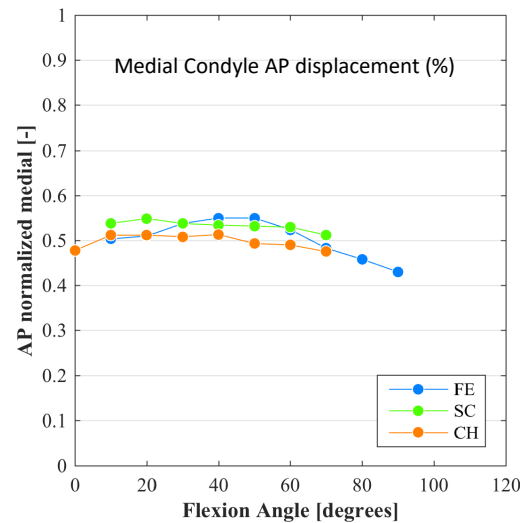
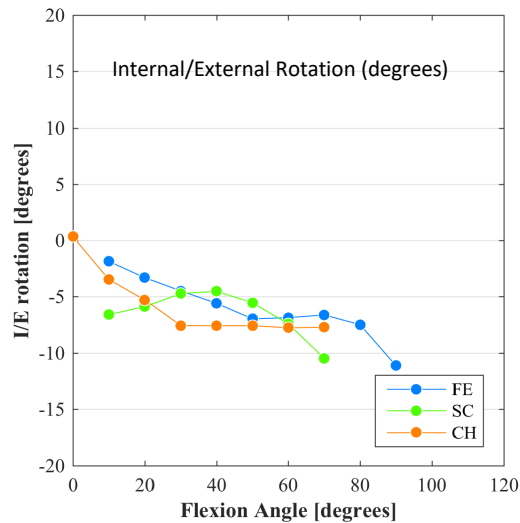
- No significant medial condyle AP displacement with knee flexion
- Slight lateral condyle posterior displacement with knee flexion
- No statistically significant differences between the two centers

# Results

Università di Modena e Reggio-Emilia



UNIMORE  
UNIVERSITÀ DEGLI STUDI DI  
MODENA E REGGIO EMILIA

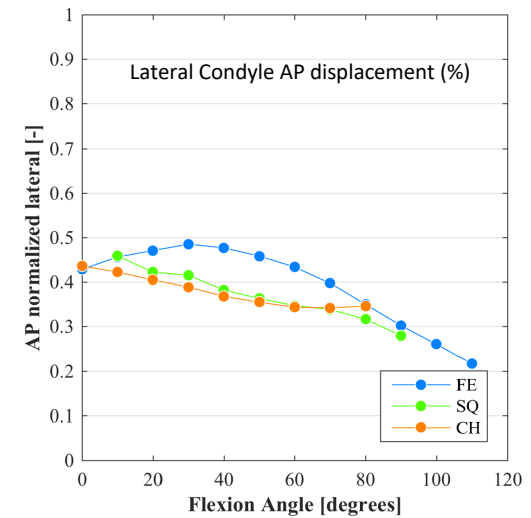
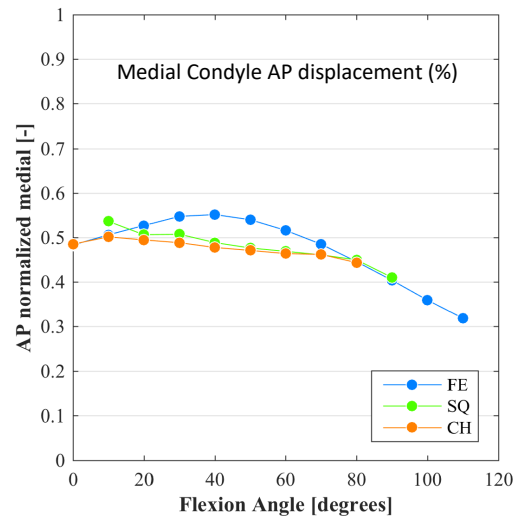
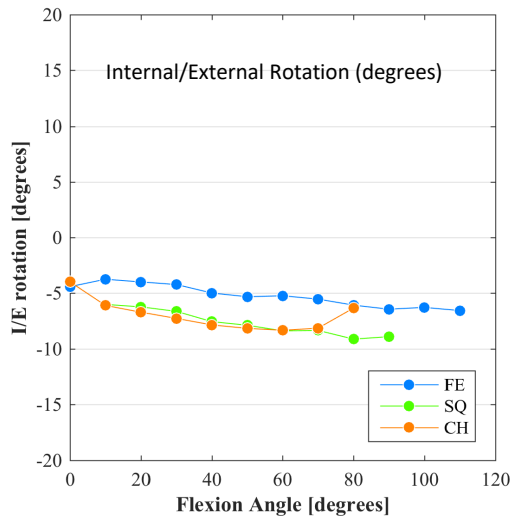


- Knee kinematics is strictly dependent on activity
- Muscle activity and external joint loading affect knee kinematics



# Results

Universiteit Gent



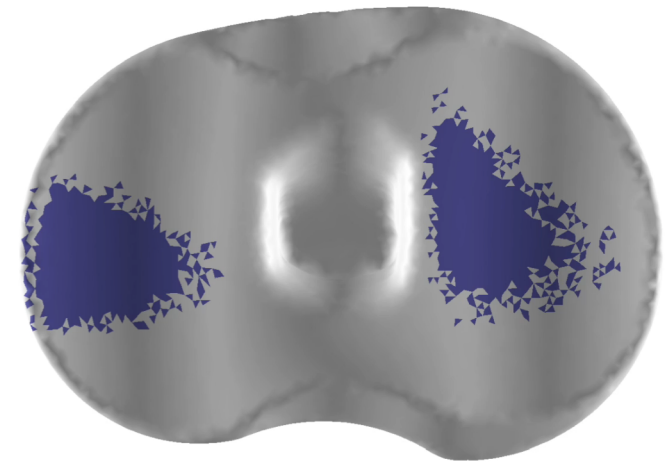
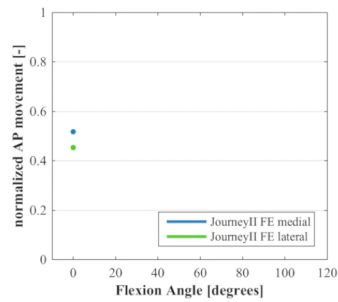
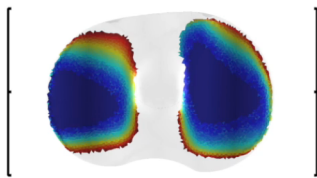
- Knee kinematics is strictly dependent on activity
- Muscle activity and external joint loading affect knee kinematics



# Results

## Flexion / Extension

Journey II BCS testMVUGentModena FE 0degree



Lateral Sagittal Intersection



Central Sagittal Intersection



Medial Sagittal Intersection

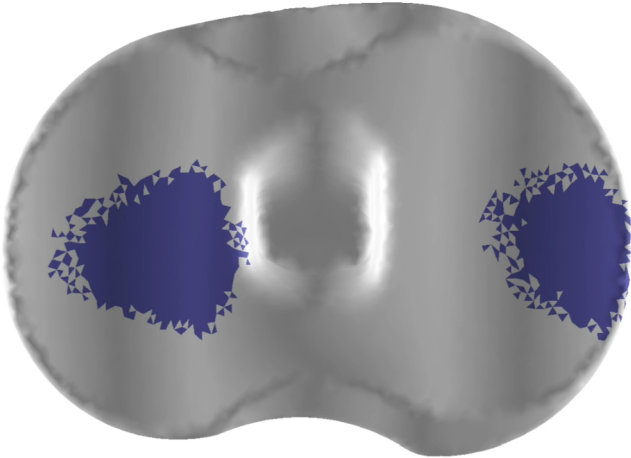
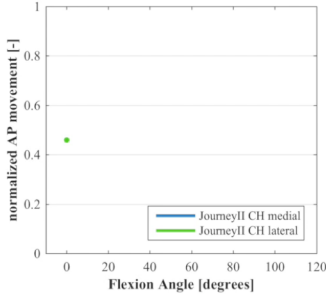
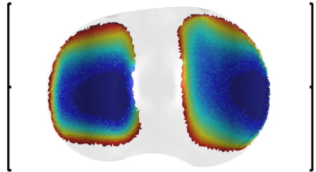


Post-Cam engagement at 50° of knee flexion

# Results

## Chair Rising

Journey II BCS testMVUGentModena CH 0degree



Lateral Sagittal Intersection



Central Sagittal Intersection



Medial Sagittal Intersection



Post-Cam engagement at 80° of knee flexion

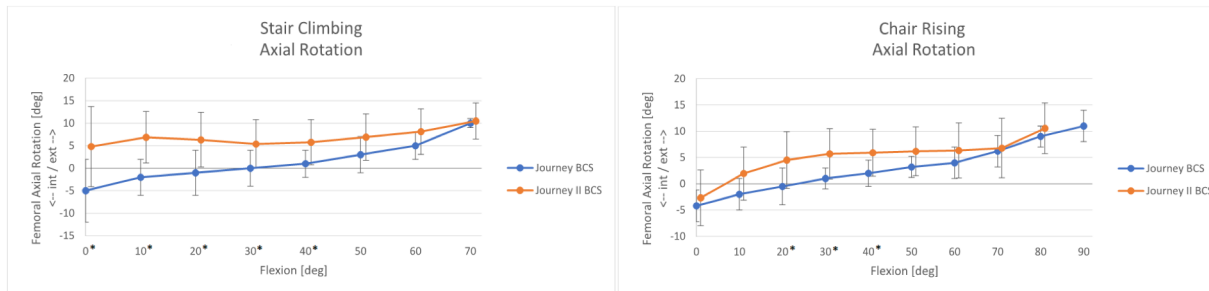


# Conclusions

- 16 Journey II BCS patients compared with 16 Journey BCS patients during two close chain motions

Catani F. et al J Orthop Res., 2009

- Similar patterns of femoral axial rotation with flexion
- Reduced absolute values of medial and lateral condyles posterior displacement in Journey II BCS
- Design changes in the recently-introduced total knee system contributed to modify its in-vivo knee kinematics



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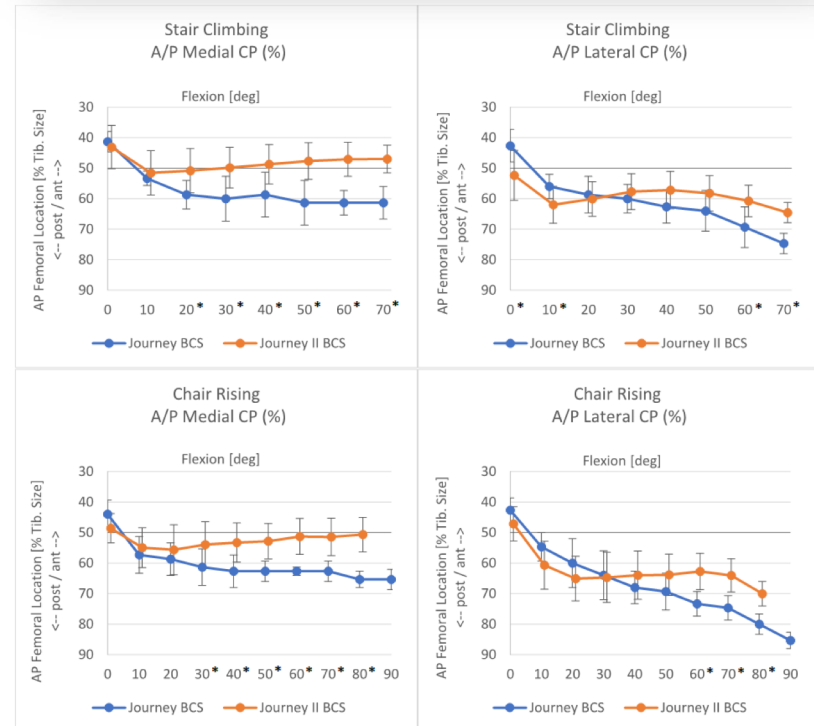
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Changes in total knee arthroplasty design affect in-vivo kinematics in a redesigned total knee system: A fluoroscopy study

Francesco Zambianchi\*, Francesco Fiacchi, Vincenzo Lombardi, Luca Venturelli, Andrea Marcovigi, Andrea Giorgini, Fabio Catani

Department of Orthopaedic Surgery, Azienda Ospedaliero Universitaria di Modena, University of Modena and Reggio Emilia, Via del Pozzo, 71, 41124 Modena, Italy





# Conclusions

- Consistent kinematic patterns between the two centres (Università di Modena and Universiteit Gent)
- Less «guided» knee kinematic pattern (open chain  $\neq$  closed chain)
- Reduced posterior translation of medial and lateral side compared to the first design
- More posterior tibio-femoral position translation on the lateral side compared to medial
- Future addressings: correlation between knee kinematics and patient's satisfaction