# Arthroplasty in the Athlete
# *MAKO Robotic Technology*

John E. Kilgore, MD

# Disclosures

- Consultant for Stryker

# Osteoarthritis

Most Common Joint Disorder in US

- 15,000,000 have OA of the Knee

Lifetime risk of Symptomatic OA

- 40% for men
- 47% for women

Murphy L, Schwartz TA, Helmick CG, et al. Lifetime risk of symptomatic knee osteoarthritis. Arthritis Rheum 2008;59(9):1207–13

# Etiology

**Interplay between Intrinsic and Extrinsic factors**

**Intrinsic**

Age

Gender

Genetics

**Extrinsic**

Obesity

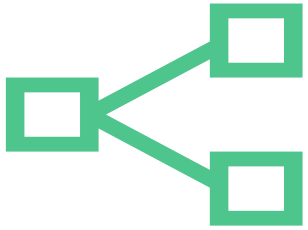
Injury/Occupation

Alignment

# Intrinsic Factors

## Age

Cumulative exposure to environmental stresses



## Gender

Female gender is associated with increased risk for development of OA

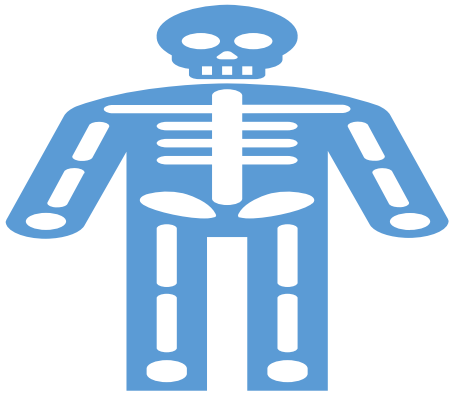
Possible hormonal relationship

Other factors such as alignment

## Genetics

Heritable component estimated to be 50 – 65%

Predisposition to extrinsic factors



**Obesity**

Increased lifetime risk for development of OA to 60%

Increases risk of development of OA due to injury or occupation

**Occupation/Injury**

Occupations Requiring Carrying, Repetitive Kneeling or Squatting

Athletes

**Alignment**

# Extrinsic Factors

# Alignment

## OA Development

- Varus alignment increases risk by 2X
- Valgus alignment increases risk by 54%

## OA Progression

- Varus alignment has a 4X increased risk
- Valgus alignment has a 5X increased risk

# Alignment

75% of compressive loads born in medial compartment of a neutrally aligned knee

Increase of 4-6% in Varus alignment can increase loading of the medial compartment by 20%

Participation in weight bearing sports predisposes development of Varus alignment in adolescent athletes

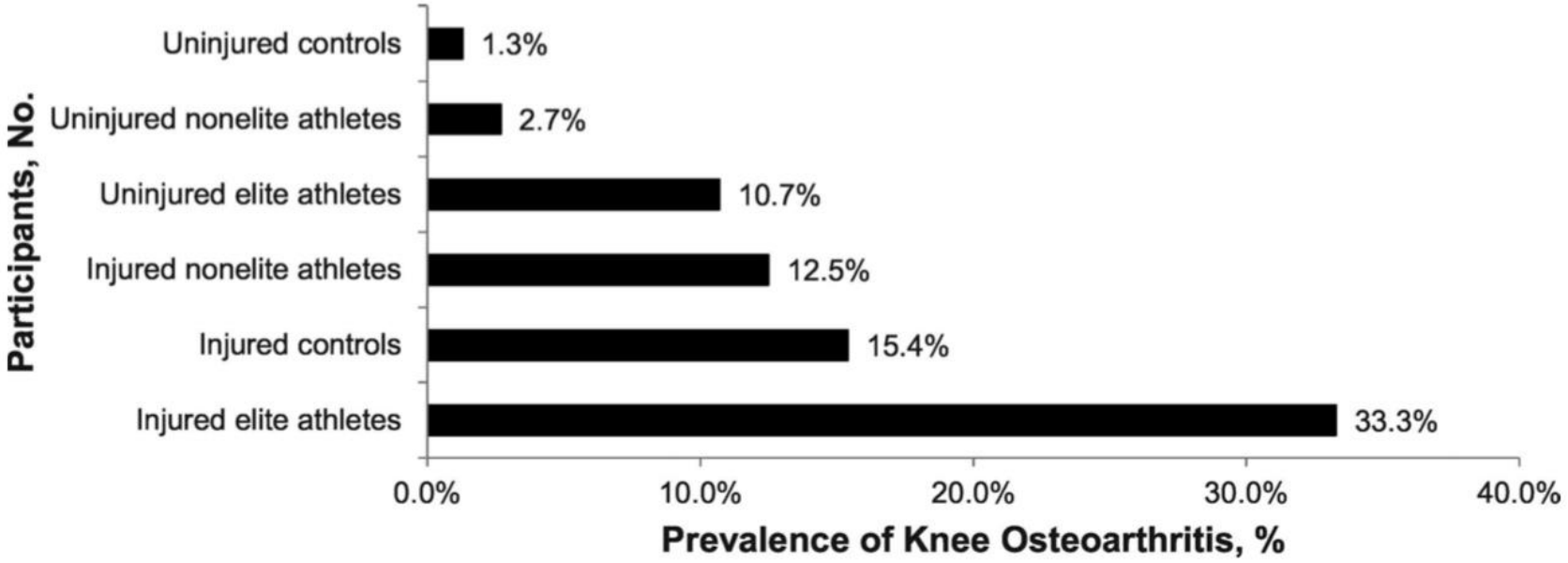
Proportion of athletes with Varus alignment of the knees is higher

# Athletes are predisposed to the development of Osteoarthritis

- Repetitive High Impact Activity
- Endure excessive loads
- Varus Alignment
- Long- distance running, soccer, weight lifting, and wrestling had a prevalence of OA 3 to 7 times that of controls*
- American football was also associated with a 9 times higher prevalence of knee OA*
- Injuries are common

*Journal of Athletic Training 2017;52(6):497–506

# Injury in Athletes and prevalence of OA




Journal of Athletic Training 2017;52(6):497–506

## Arthroscopy

Reported rates of TKA at 1, 2, and 3 years after arthroscopy were 10.1%, 13.7%, and 15.6%, respectively

Orthopedics. 2016 Nov 1;39(6):e1041-e1044

## Meniscectomy

132 fold increase in rate of TKA compared to age-matched pairs

J Bone Joint Surg Br. 2012 Dec;94(12):1649-54

# ACL Reconstruction

- Yields a lower cumulative incidence of OA development and TKR
- 7 times greater risk of Knee Arthroplasty compared to matched controls

- J Bone Joint Surg Am. 2014 Jan 1;96(1):2-10

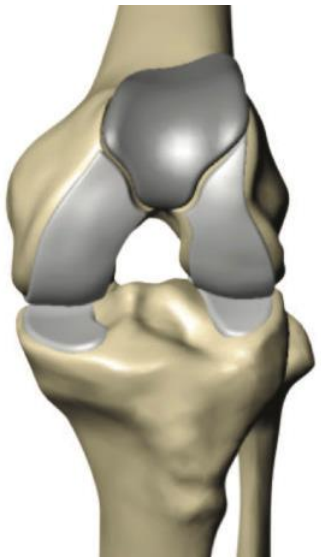
# Knee Arthroplasty

- INDICATIONS: OA with Pain and/or functional impairment which fails to respond to conservative treatment
- In up to 19% of patients who were candidates for Joint Arthroplasy, return to sports was the primary indication


- Meneghini RM, Russo GS, Lieberman JR. Modern perceptions and expectations regarding total knee arthroplasty [published online June 17, 2013]. J Knee Surg

# KNEE ARTHROPLASTY OPTIONS

MEDIAL



PATELLOFEMORAL

LATERAL

TOTAL KNEE

# Arthroplasty in the Athlete

- 61.4% of 726 patients returned to their previous sport in some capacity*
- 27% of patients decreased their activity secondary to pain, which led to the conclusion that patients should be cautioned against expecting to return to high-impact sports*
- UKA had higher return to athletic participation than those with TKA**

*Wylde V, Blom A, Dieppe P, et al. Return to sport after joint replacement. J Bone Joint Surg Br. 2008;90:920-923.

**Hopper GP, Leach WJ. Participation in sporting activities following knee replacement: total versus unicompartmental. Knee Surg Sports TraumatolArthrosc. 2008;16:973-979

# How Long Does it Last?

- Pooled Registry data indicates that for:
  - TKA, survival at 25 yrs is 82%
  - UKA 25 year survival is 69%

- SURVIVAL is dependent upon:
  - Age at time of procedure
  - Activity level
  - Other extrinsic factors such as BMI
  - ***Surgical Technique—Alignment and Balance***

# WHY ARE WE CONCERNED ABOUT BALANCE AND ALIGNMENT?

# POSTOPERATIVE ALIGNMENT OF TKR

*RITTER ET AL, CLIN ORTHOP 1994*

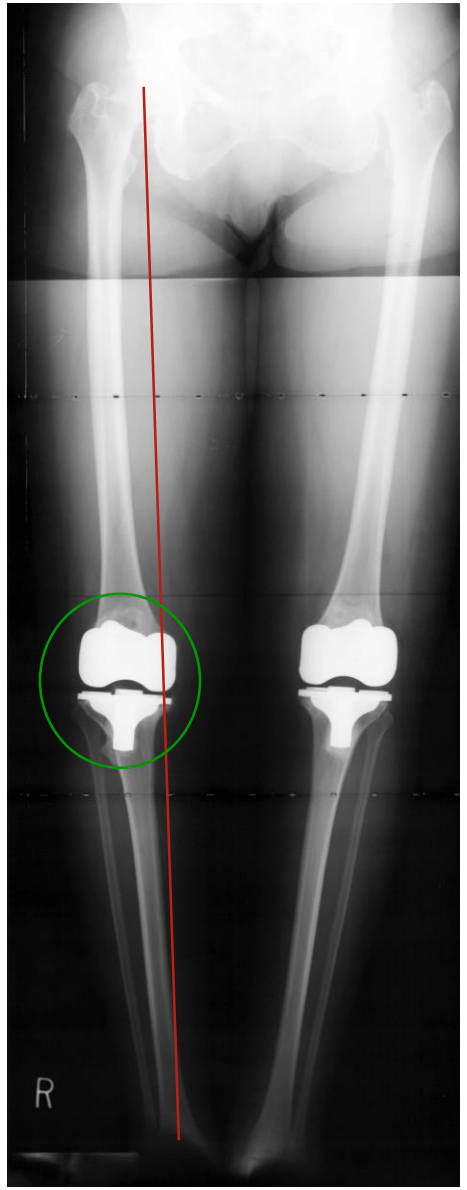
| Primary TKR | Number of Cases | Percent EARLY REVISION |
|---|---|---|
| Varus > 3° | 35 | 14% |
| Neutral | 244 | 1% |
| Valgus > 3° | 82 | 0% |

NOTE: 32% MALALIGNED

# VARUS MALALIGNMENT

- FINITE ELEMENT ANALYSIS
- 145.9% INCREASE IN POLYETHYLENE CONTACT STRESSES
- *Liau et al, Clinical Biomechanics 2002*

- IN VITRO LOADING OF TKR IN CADAVER TIBIA
- 86.6% INCREASE IN POLYETHYLENE STRAIN
- *Green et al, J Arthroplasty 2002*



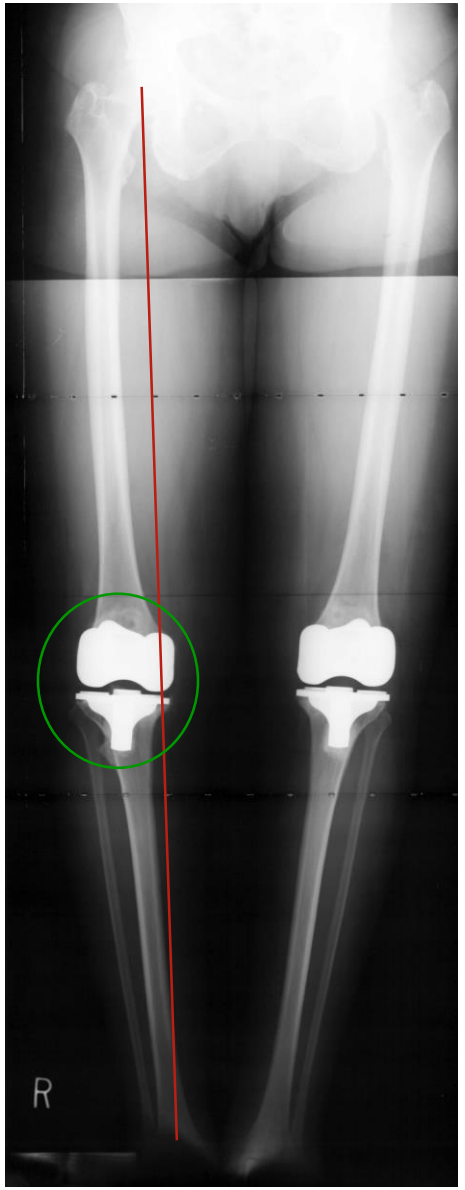
VARUS ALIGNMENT

# FINITE ELEMENT ANALYSIS
# 145.9% INCREASE IN POLYETHYLENE CONTACT STRESSES

*Liau et al, Clinical Biomechanics 2002*

# IN VITRO LOADING OF TKR IN CADAVER TIBIA
# 86.6% INCREASE IN POLYETHYLENE STRAIN

*Green et al, J Arthroplasty 2002*



# WHY SHOULD WE BE CONCERNED ABOUT BALANCE AND ALIGNMENT?

# The Dirty Truth

Only 81% of patients are SATISFIED with their Total Knee Replacement in terms of pain relief and function

Patient Satisfaction after Total Knee Arthroplasty: Who is Satisfied and Who is Not?

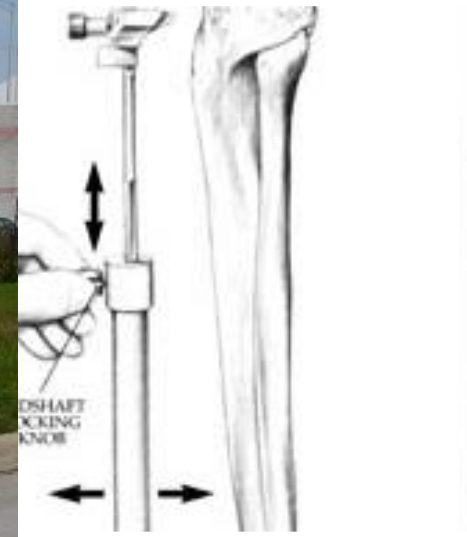
# Reasons for TKA Revision

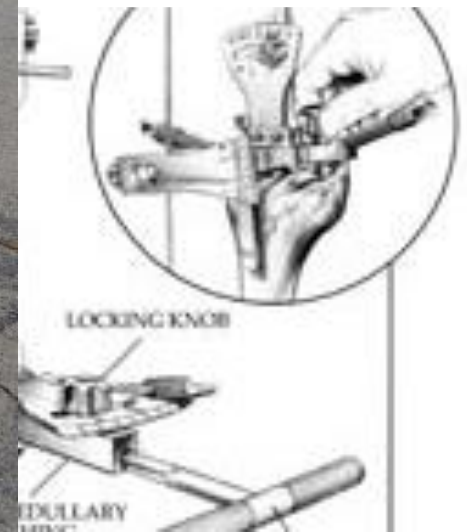
50% were performed <2 yrs
After Index Surgery

## 33% Of Early Revisions Performed Due to:

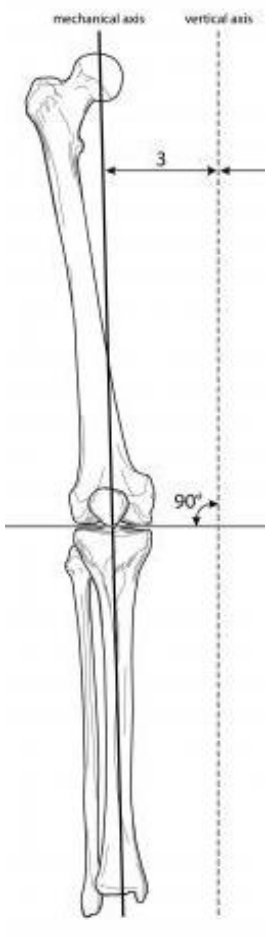
- Component Malposition & Malalignment
- Instability/Poor Balance

Sharkey PF, et al: Why are knee replacements failing today? Knee Society, 2002


DSHAFT
CKING
KNOB


LOCKING KNOB
EDULLARY

# Conventional Instrumentation




## META-ANALYSIS

Bathis, H, et al Orthopade 2006 Oct (10):1056-65

- 13 Studies
- “Safe Zone” +/- 3˚ from Neutral Mechanical Axis
- Only 75.6% of Knees met Criteria

# Instrumentation for Unicompartmental Arthroplasty

- Less Accurate than TKA
- Poor Reproducibility

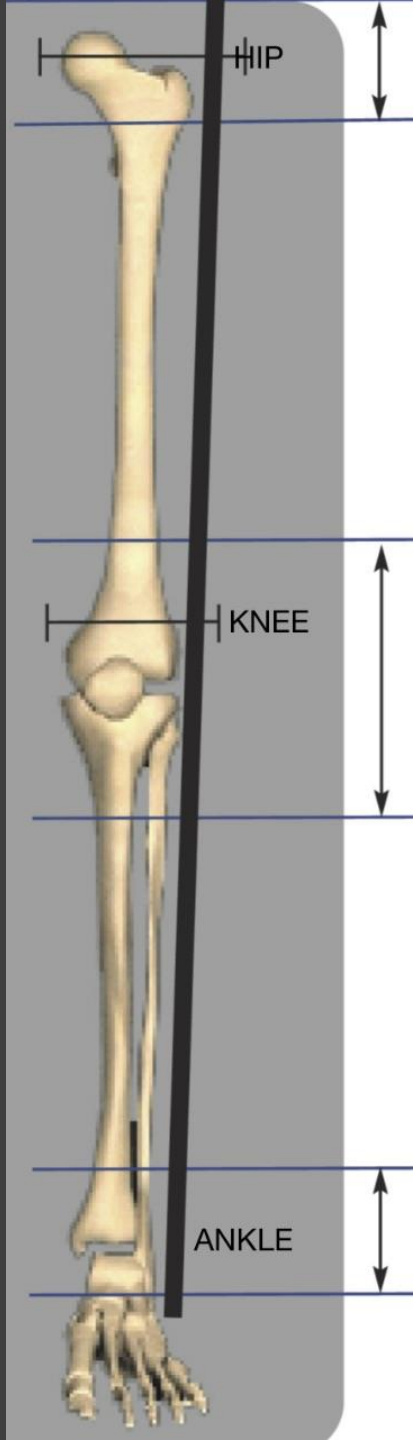
# Notoriously Inconsistent Results

# Take Advantage of Available Technologies

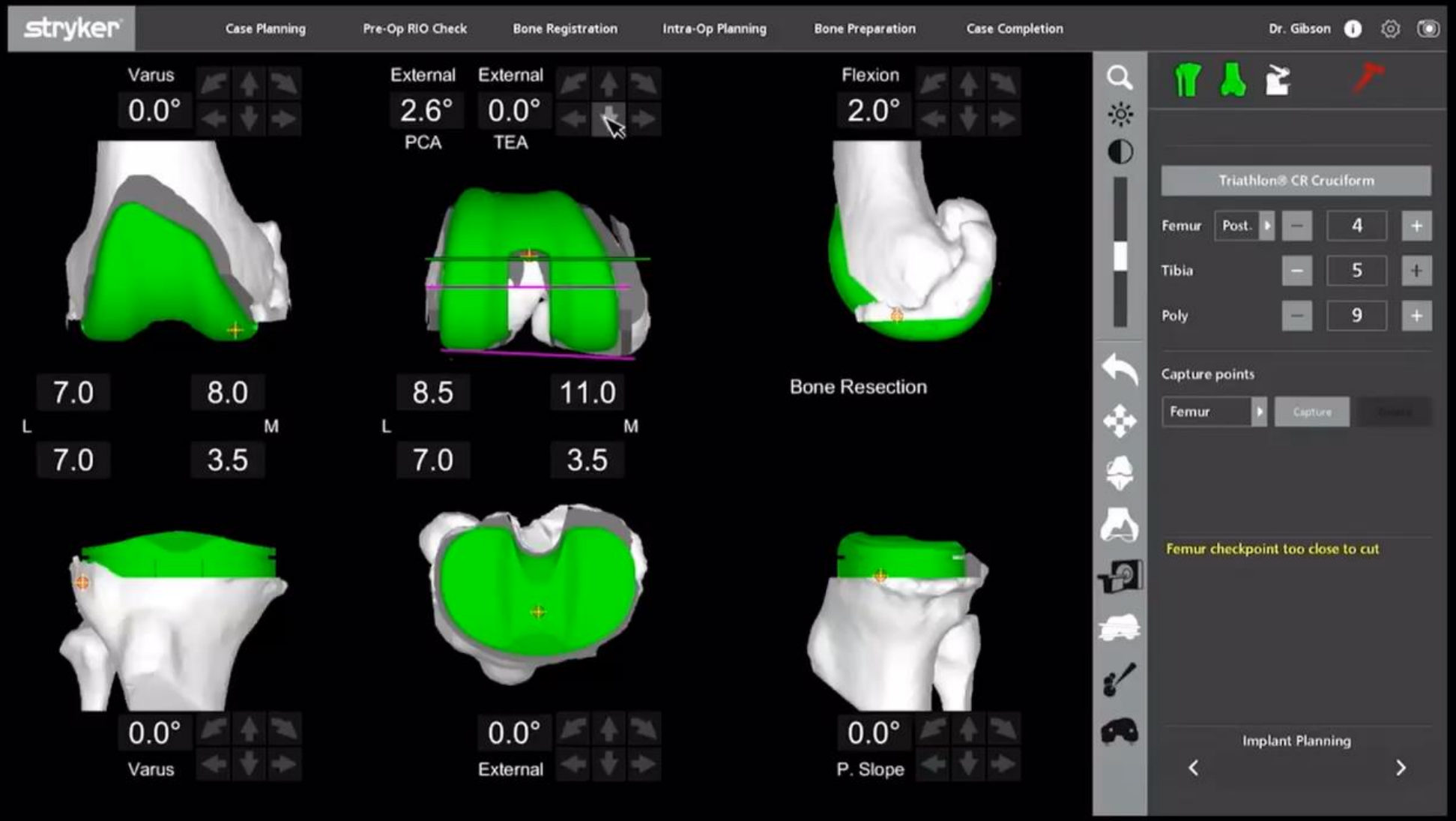

# MAKO ROBOTIC ARM ASSISTED ARTHROPLASTY

- 3-Dimensional Pre-operative Planning
- Accurate Intra-operative Adjustments
- Haptic Guidance
- Consistent and Reproducible Results

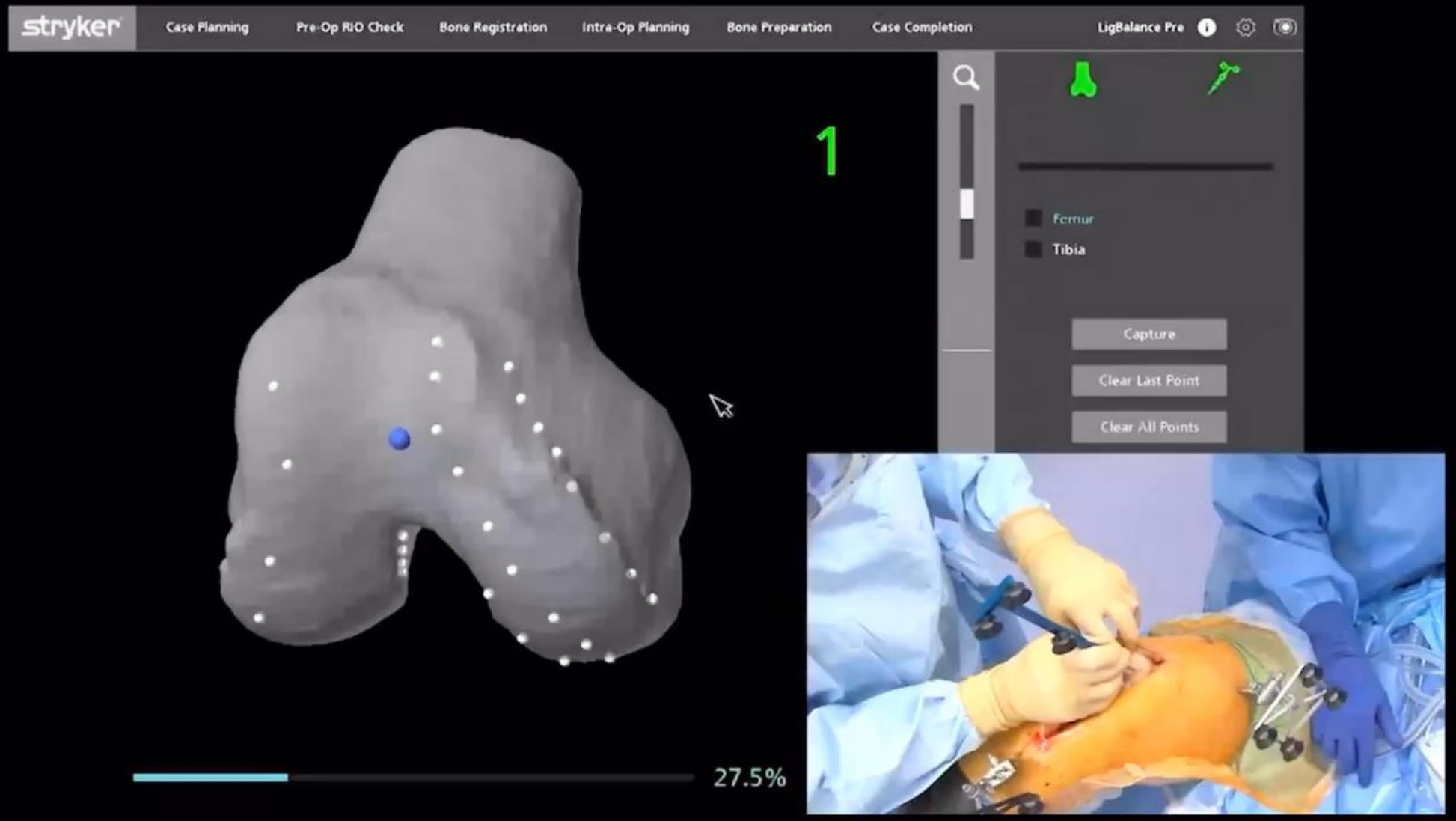

# CT scan obtained to produce a Patient-specific 3D Model



# ENHANCED PREOPERATIVE PLANNING

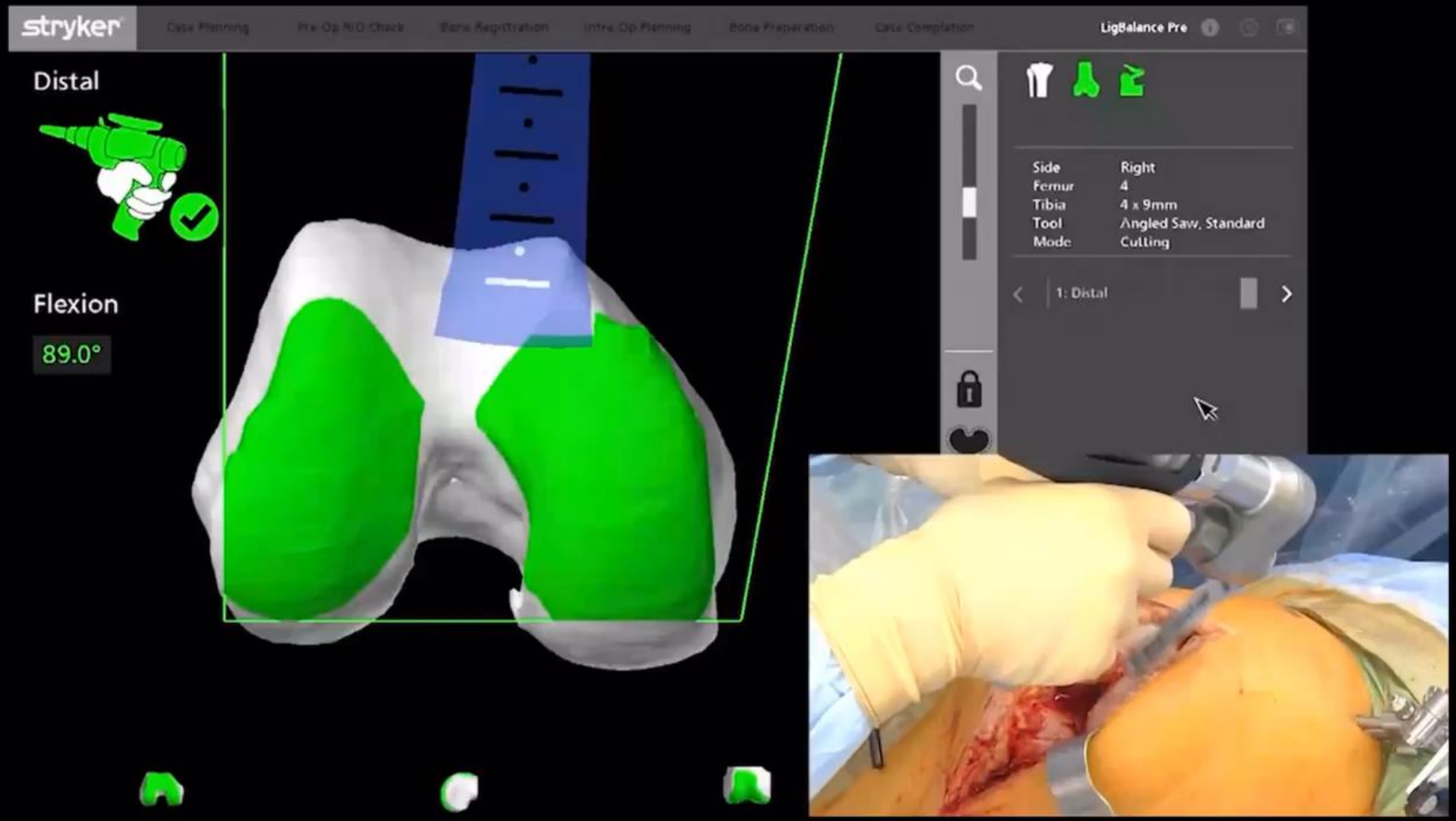


# BONE REGISTRATION



# DYNAMIC JOINT BALANCING

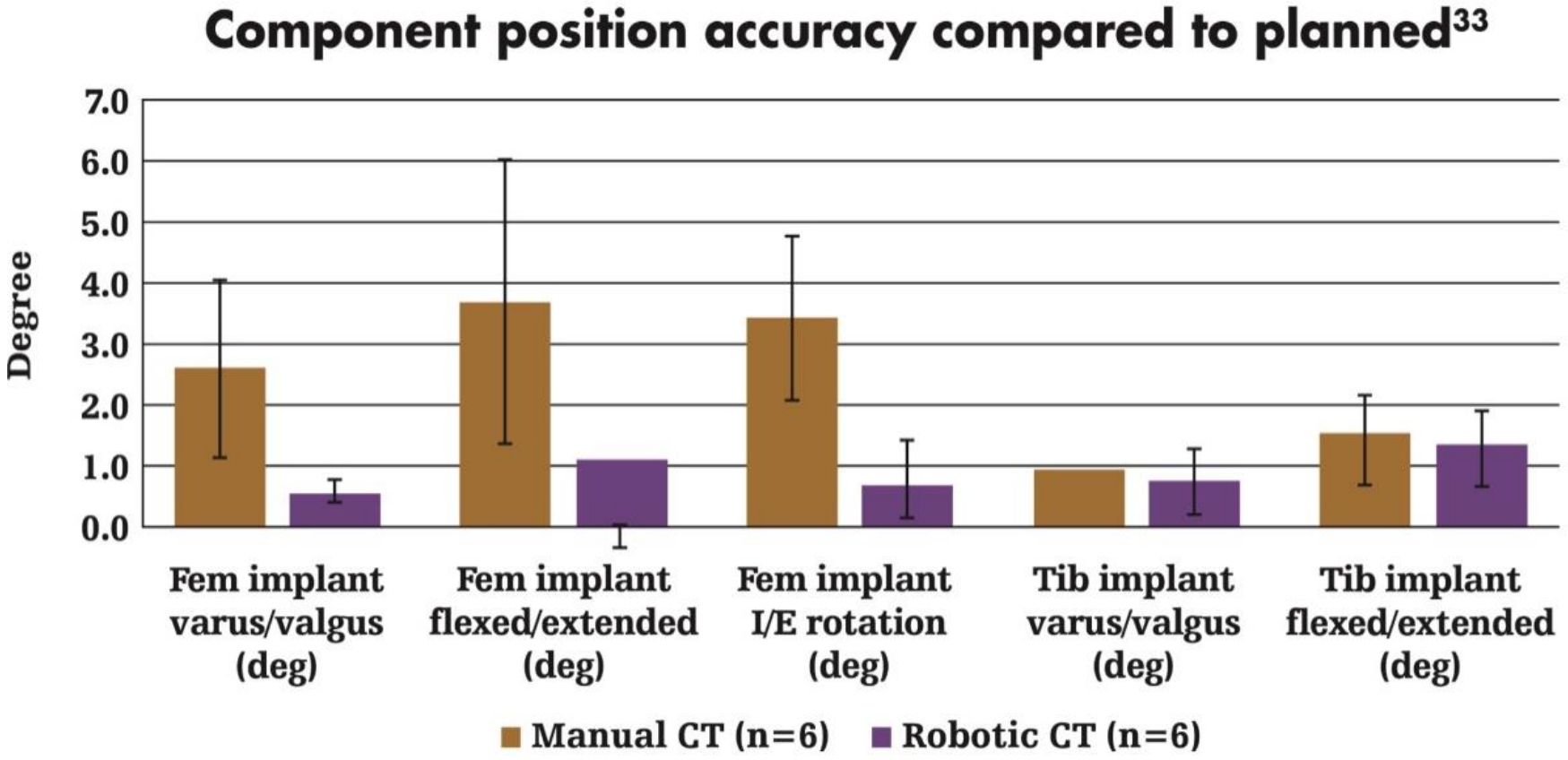
# HAPTIC GUIDANCE: CONTROL OF BONE RESECTION





# COMPLEX CASE

# Robotic Arm Assisted TKA: Greater Accuracy




Hampp EL, Chughtai M, Scholl LY et al. Robotic-arm assisted total knee arthroplasty demonstrated greater accuracy and precision to plan compared with manual techniques. J. Knee Surg. 2019 Mar;32(3):239- 250

# RESULTS: Early Functional Recovery

Less Postoperative PAIN

Decreased Blood Loss

Less Time to Straight Leg Raise

Fewer In-patient PT sessions

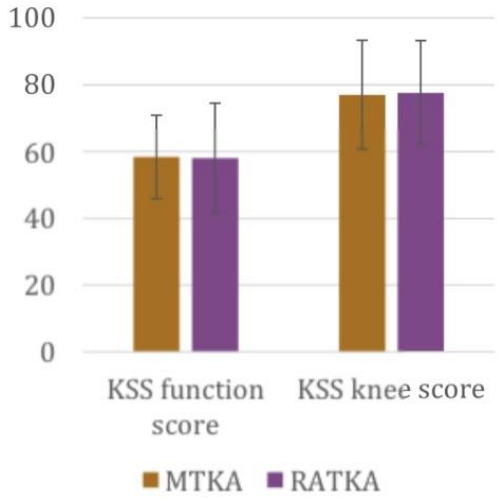
Increased Maximum Knee Flexion at Discharge

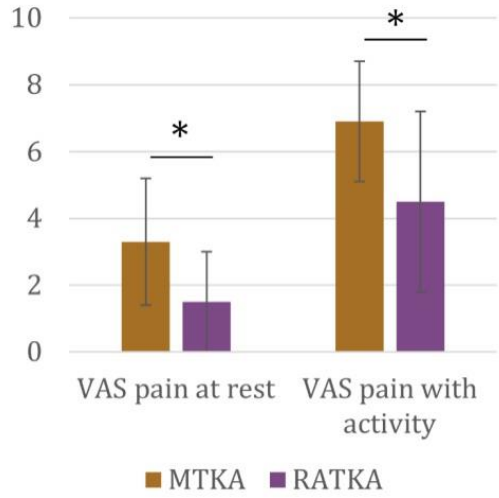
26% Reduction in length of Stay

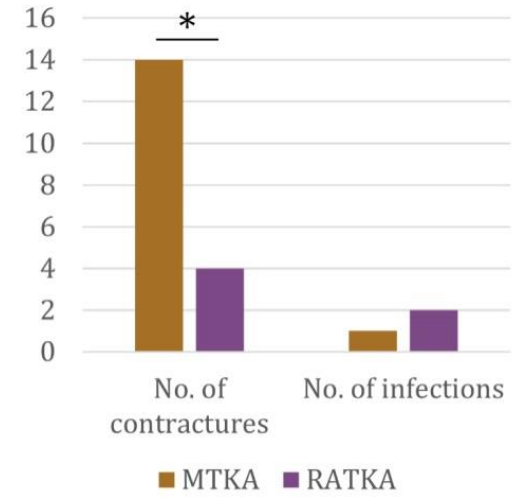
Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, Haddad FS. Robotic- arm assisted total knee arthroplasty is associated with improved early functional recovery and reduced time to hospital discharge compared with conventional jig-based total knee arthroplasty. Bone Joint J. 100(7), 930–937 (2018).

# Results: Improved Early Outcomes

## 100 Robotic TKA VS 100 Conventional TKA @ 6 weeks

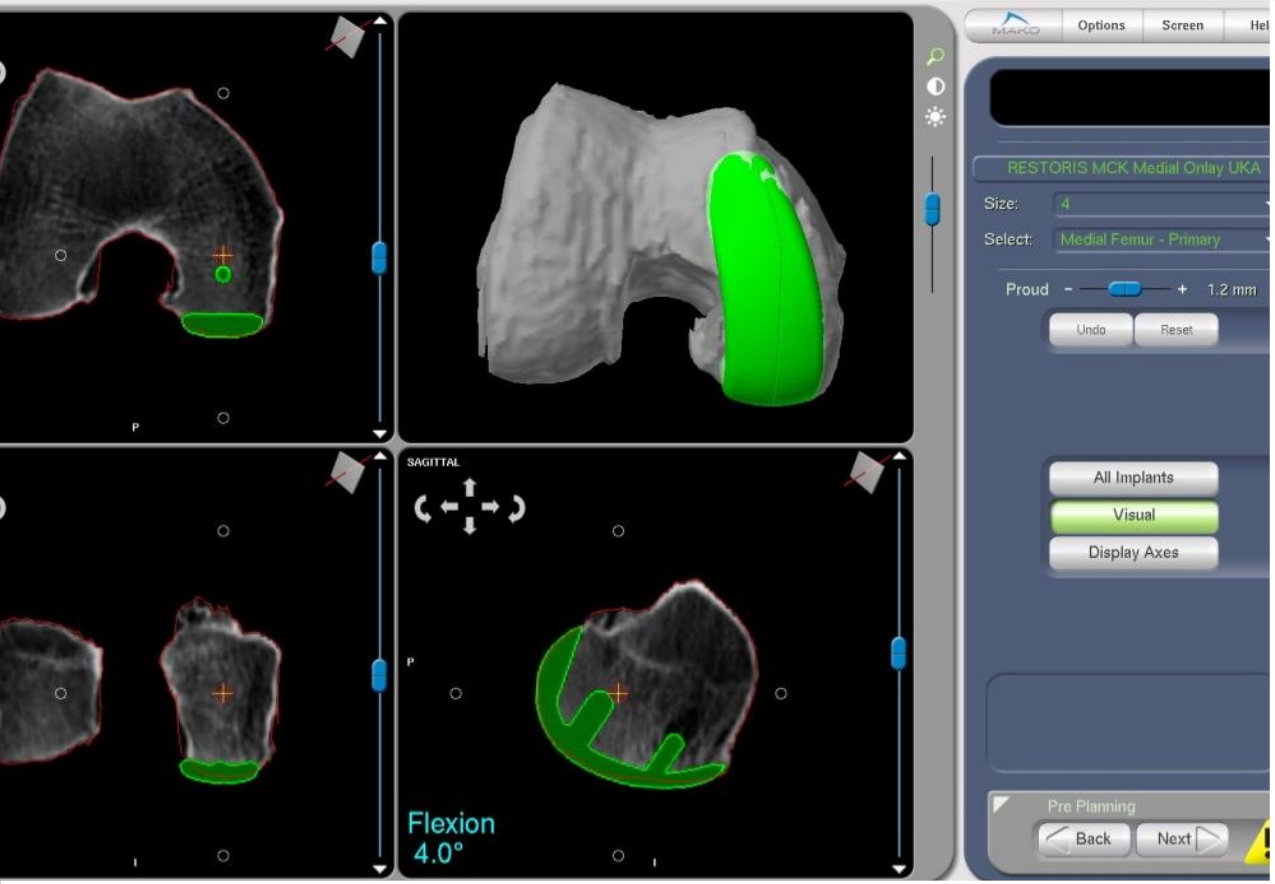


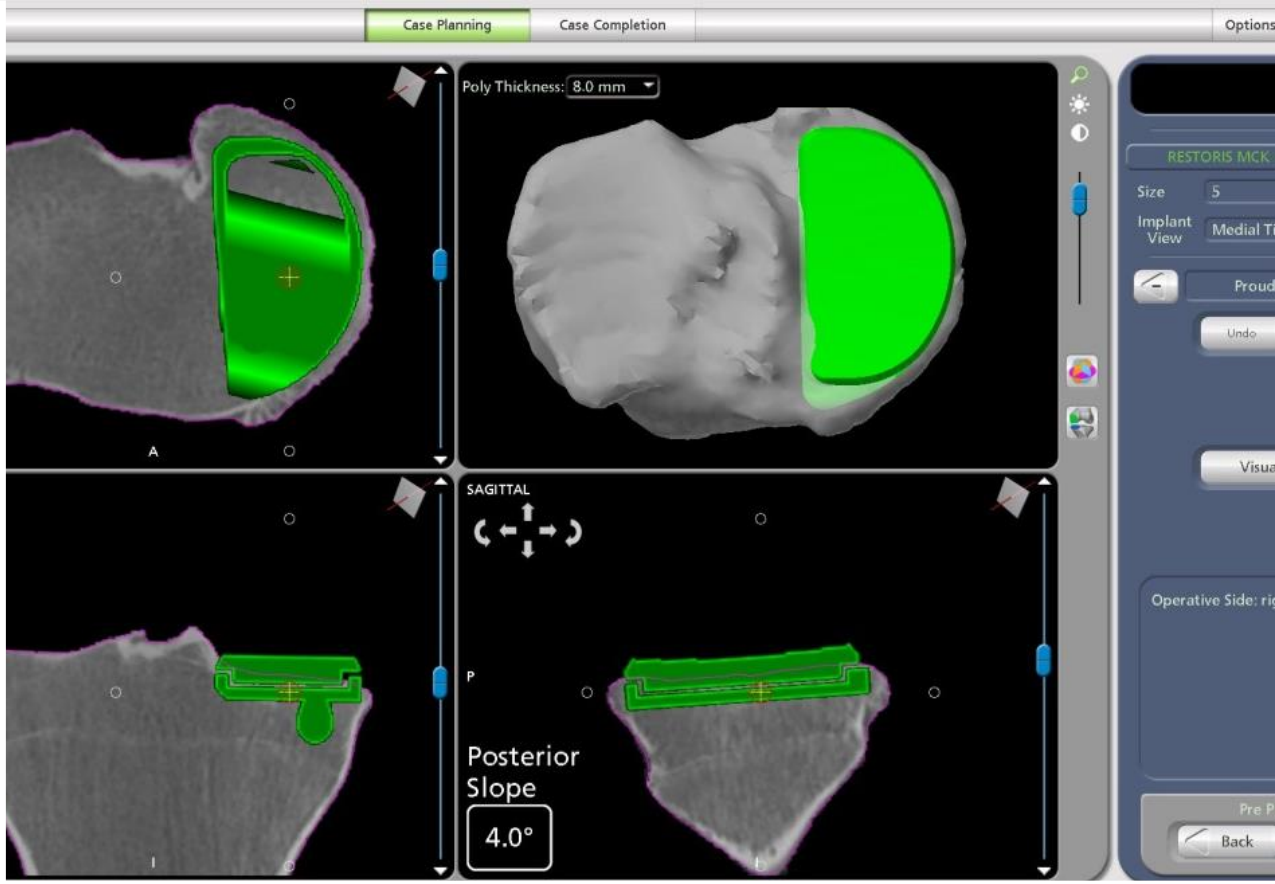




Malkani, A, et al 2018

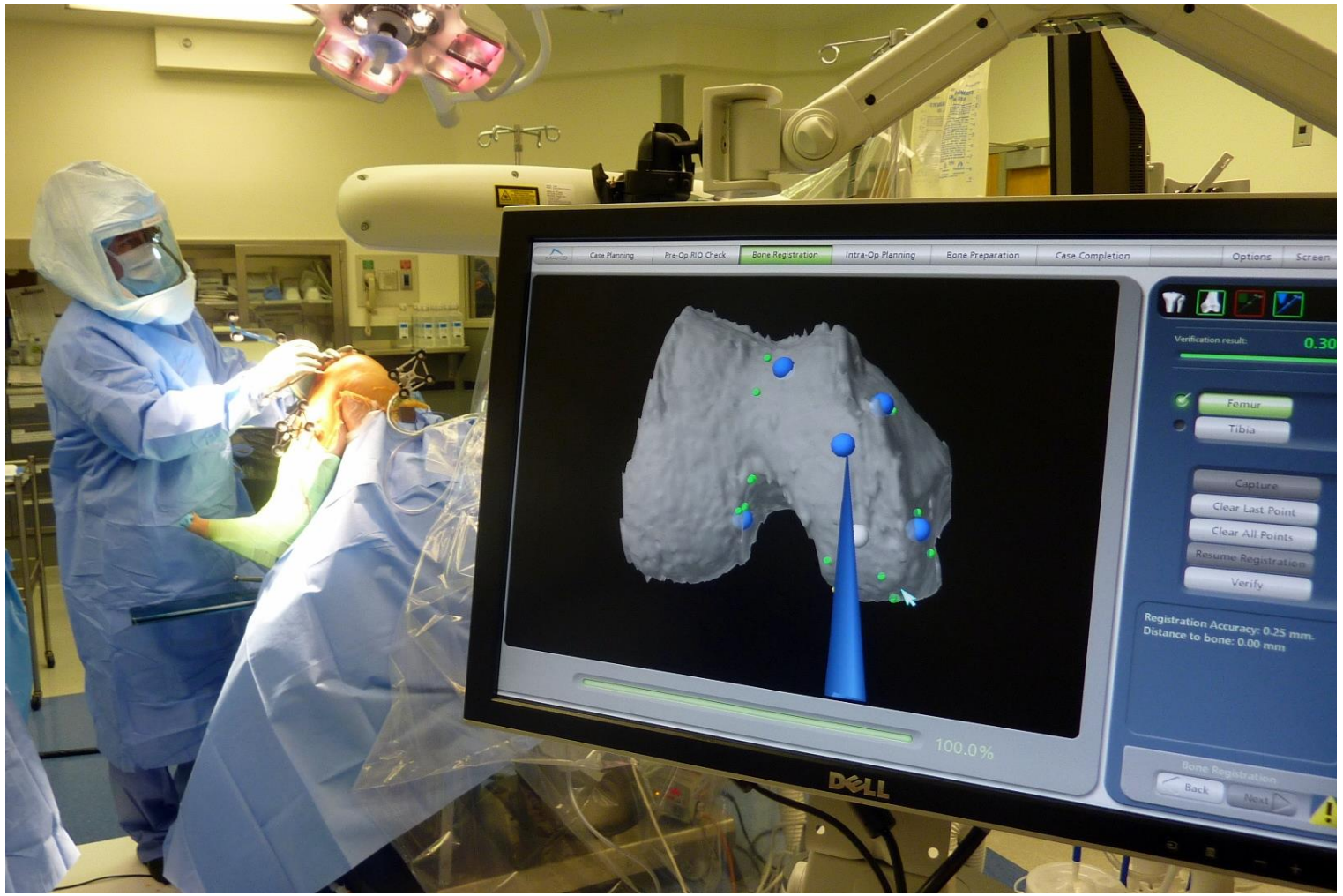
# Unicompartmental Arthroplasty



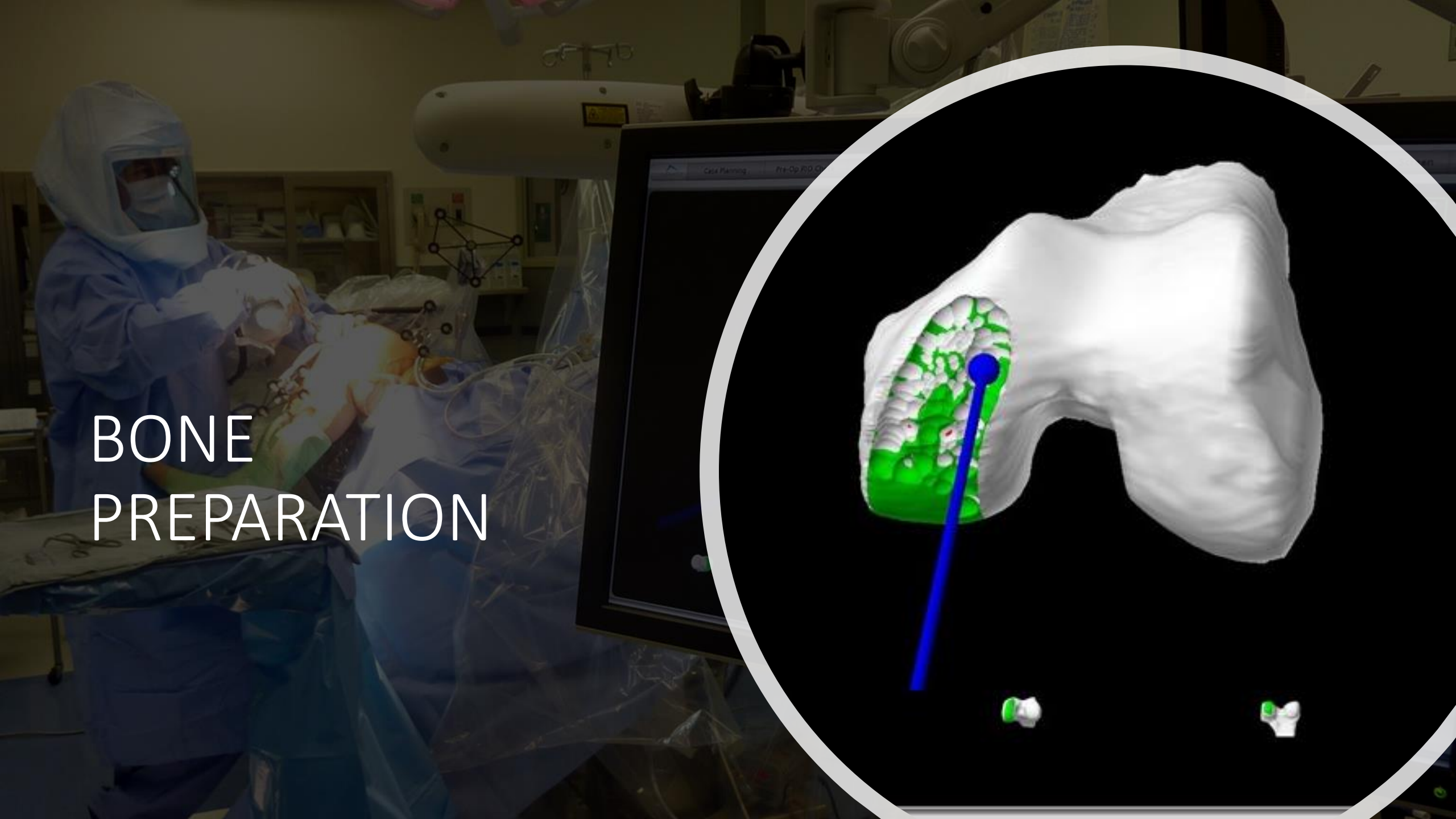

# ENHANCED PREOPERATIVE PLANNING

# Registration

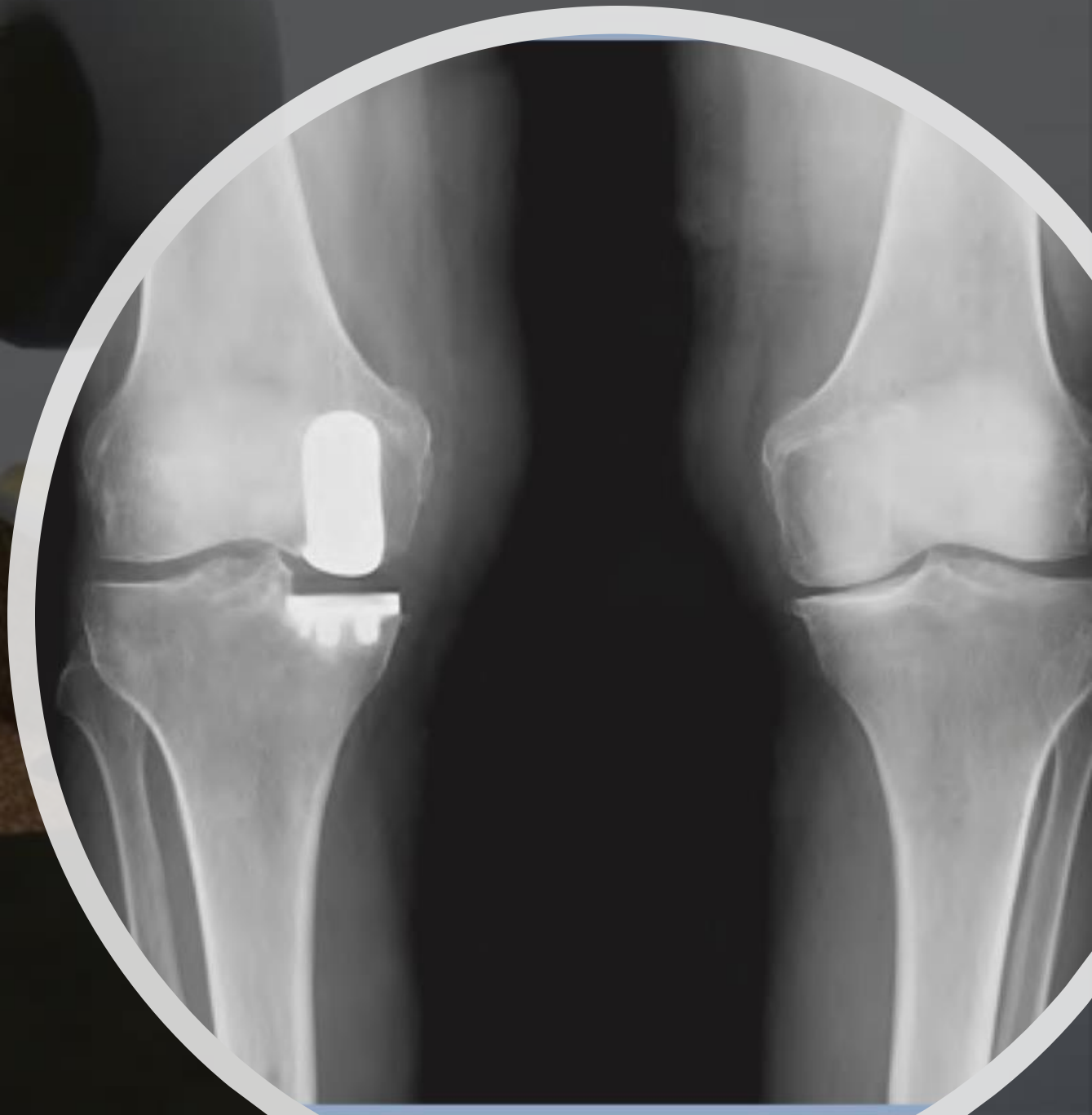


# INTRAOPERATIVE ASSESSMENT AND DYNAMIC BALANCING

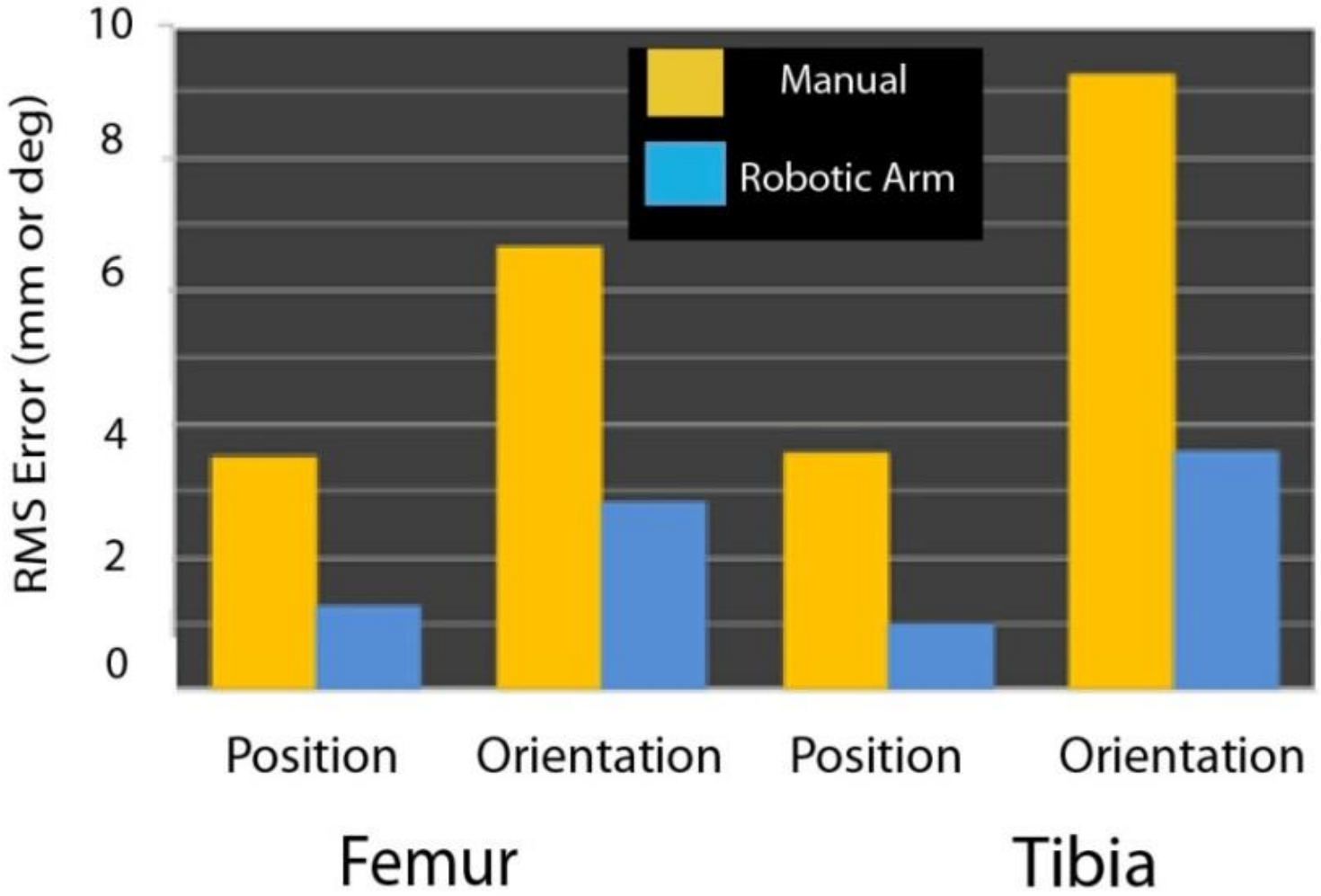
# BONE PREPARATION



RADIOGRAPHIC RESULT:
Unicompartmental Arthroplasty (UKA)

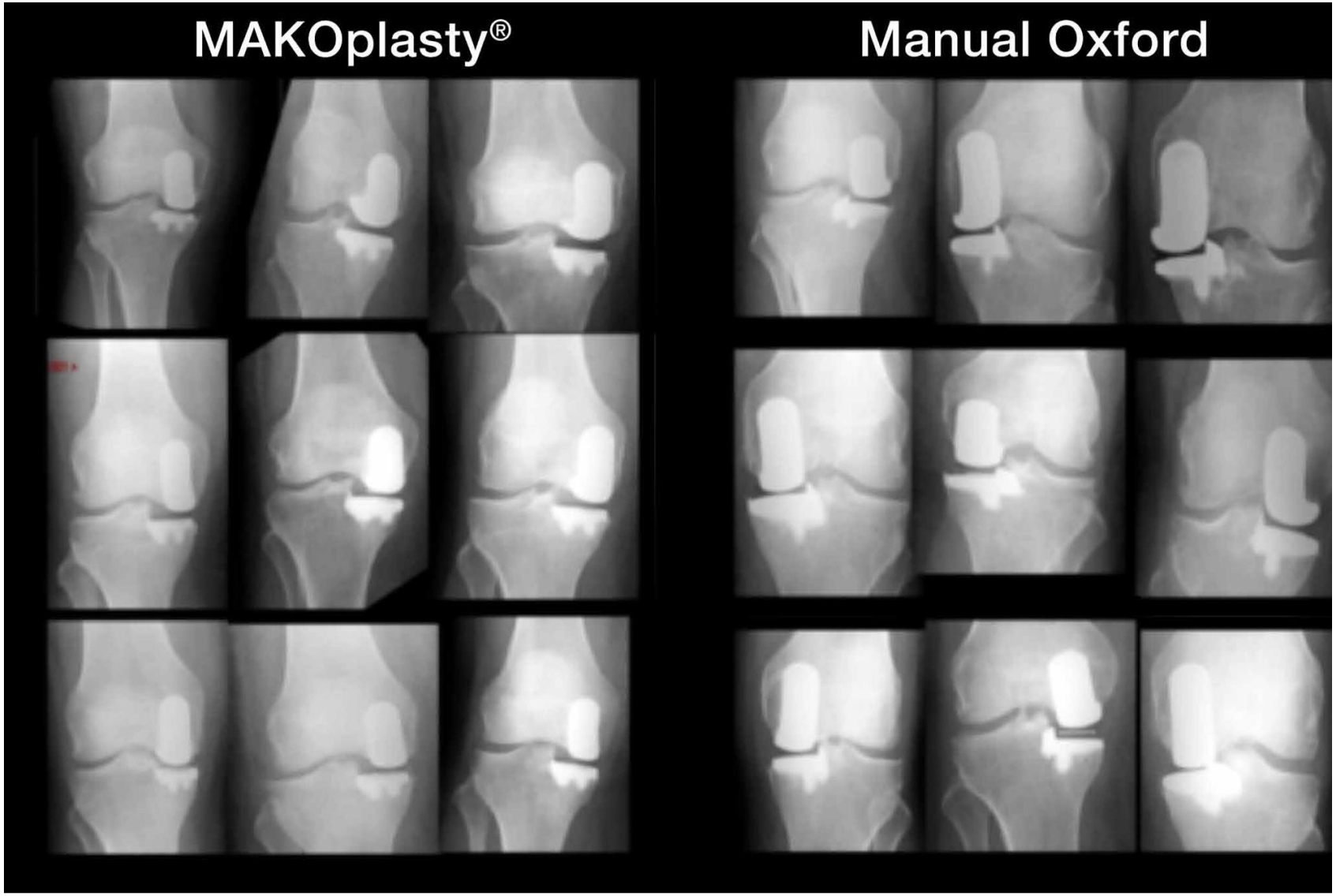


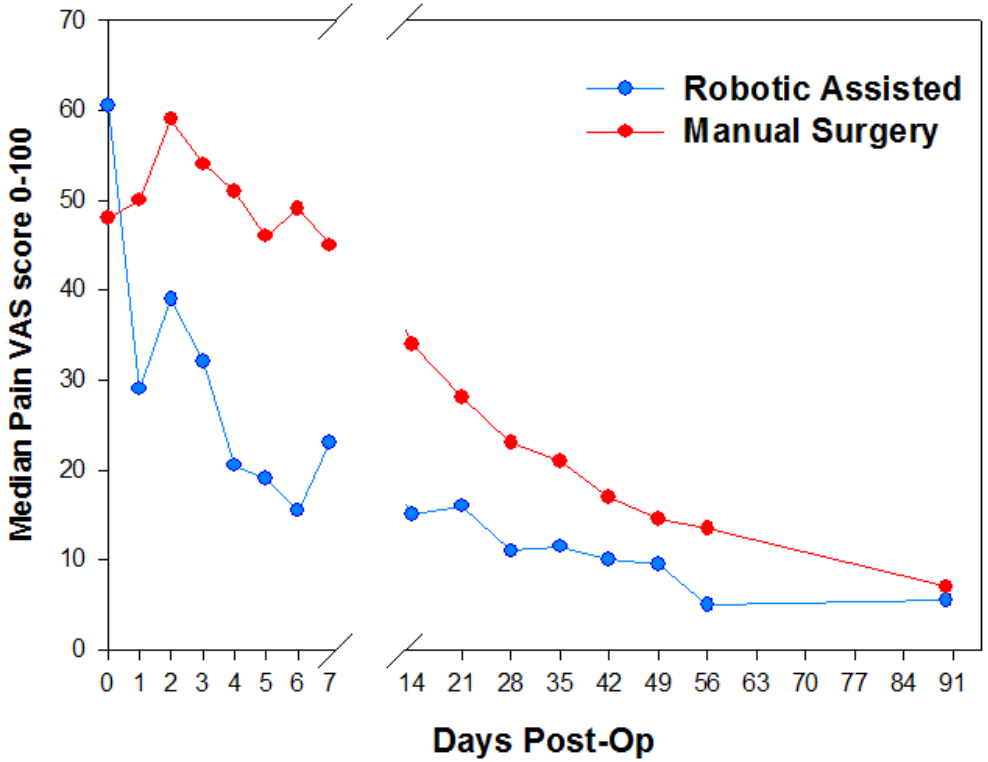
# IMPROVED ACCURACY OF IMPLANTATION




***A Randomized Controlled Trial Comparing Accuracy and Outcomes of Robotically Assisted PKA to Manual PKA***
**Principal Investigators:** Drs. Blyth, Jones, Maclean, Anthony, Rowe

# IMPROVED RADIOGRAPHIC CONSISTENCY



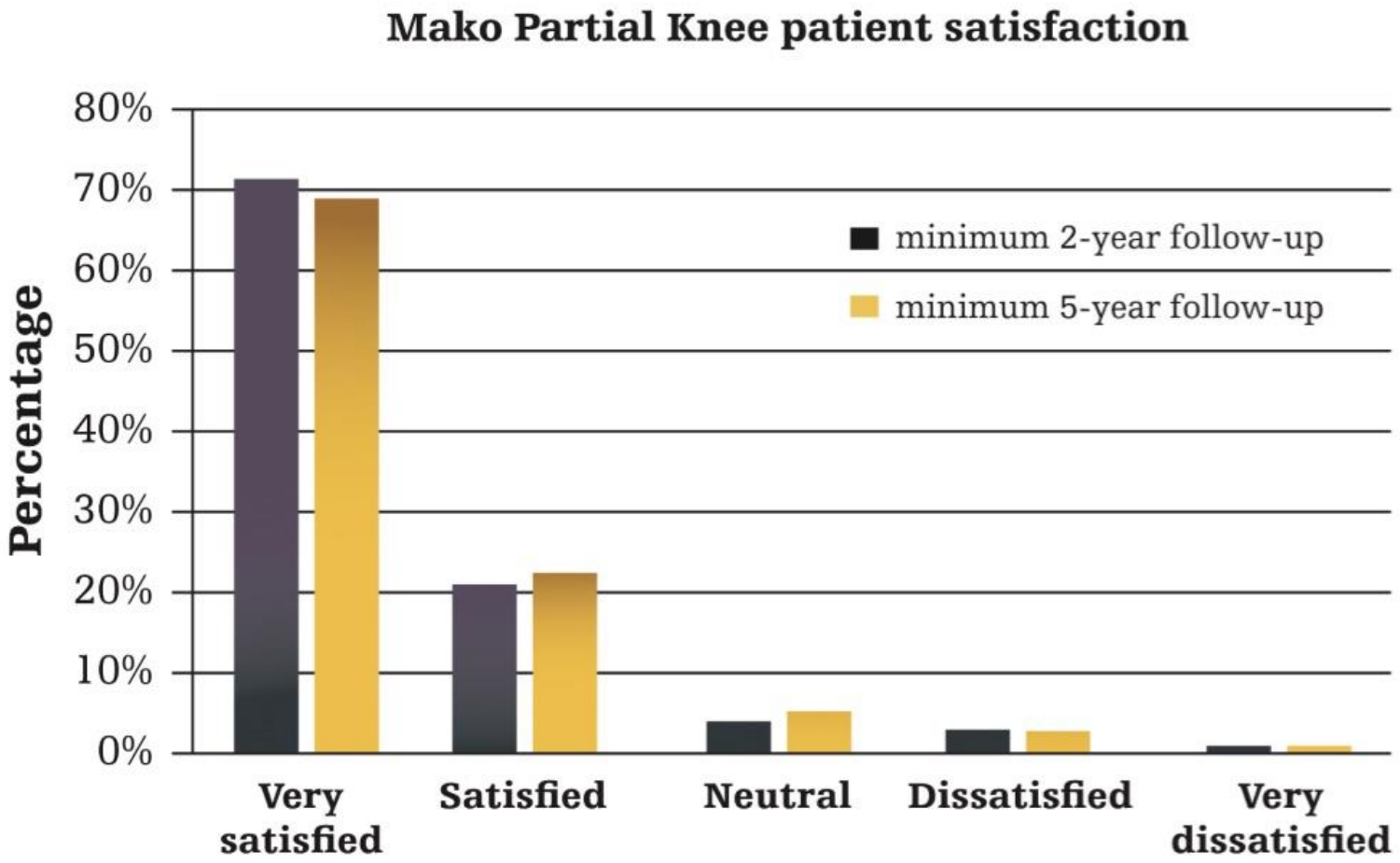



# MAKOplasty® Demonstrates Early Less Post-Operative Pain Versus Manual UKA (Oxford® )

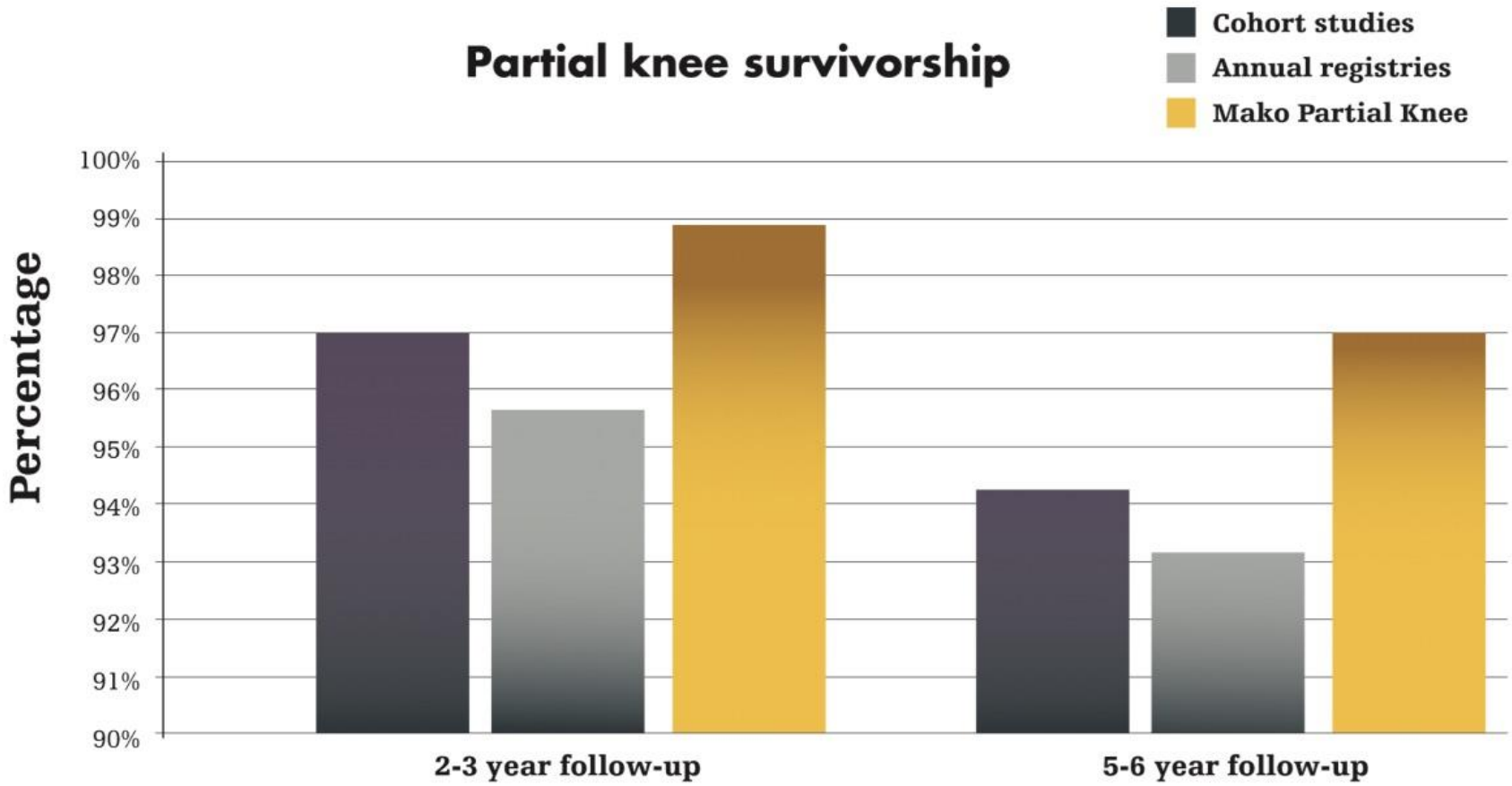
Conclusion: MAKOplasty Patients Had Significantly Less Pain than Oxford Patients Day 1 To Week 8

Jones B, Blyth M, MacLean A, Anthony I, Rowe P. Accuracy of UKA implant positioning and early clinical outcomes in a RCT comparing robotic assisted and manual surgery. CAOS International Conference, June 13-15, 2013, Orlando, Florida.

# IMPROVED PATIENT SATISFACTION LONG-TERM



# IMPROVED SURVIVORSHIP



# What Activities Are Permitted After Arthroplasty?

## A Survey of Experienced Joint Replacement Surgeons

| | |
|---|---|
|  Recommended | Walking, Swimming, Biking, Hiking, Tennis (Doubles) |
|  “Allowed with experience” or ”No Consensus” | Skiing, Weight Lifting, Hockey, Gymnastics, Tennis (Singles) |
|  Not Recommended | soccer, jogging, basketball and football |

Klein GR, Levine BR, Hozack WJ, et al. Return to athletic activity after total hip arthroplasty. Consensus guidelines based on a survey of the Hip Society and American Association of Hip and Knee Surgeons. J Arthroplasty. 2007;22:171-175

# SUMMARY

- OA is Prevalent in Athletes
  - Injuries
  - Repetitive Use
  - Varus Alignment common
- Robotic Assistance Allows for More Consistently Superior Results than Conventionally Performed Arthroplasty
- Return to many Sports is ***POSSIBLE***