Knee Replacement

Current Alignment Strategies & Robotics

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Forté SPORTS MEDICINE AND ORTHOPEDICS

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Knee Arthritis

Inflammation and deterioration of knee joint **cartilage & bone**.

Pain

Swelling

Stiffness

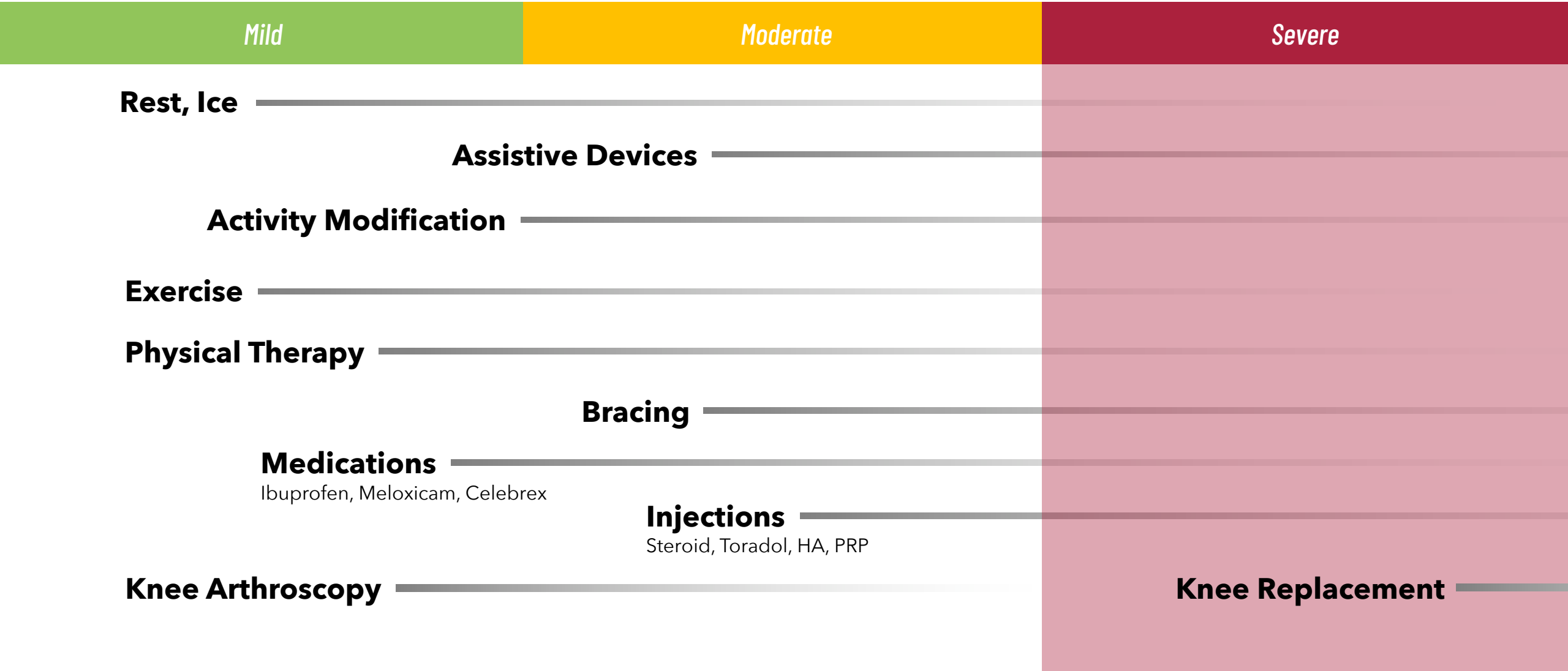
Limited range of motion

Instability

Spectrum

Mild	Moderate	Severe

Treatment Options



Knee Replacement

Resurfacing of the distal femoral, proximal tibial and patellar articular surfaces, replacing damaged cartilage surfaces with metal and plastic surfaces.

Why? When?

Severe knee arthritis causing pain and disability that non-operative treatments have failed to relieve.

Non-operative treatment

Weight loss
Physical therapy & exercise
Medications
Brace
Injections

Effective

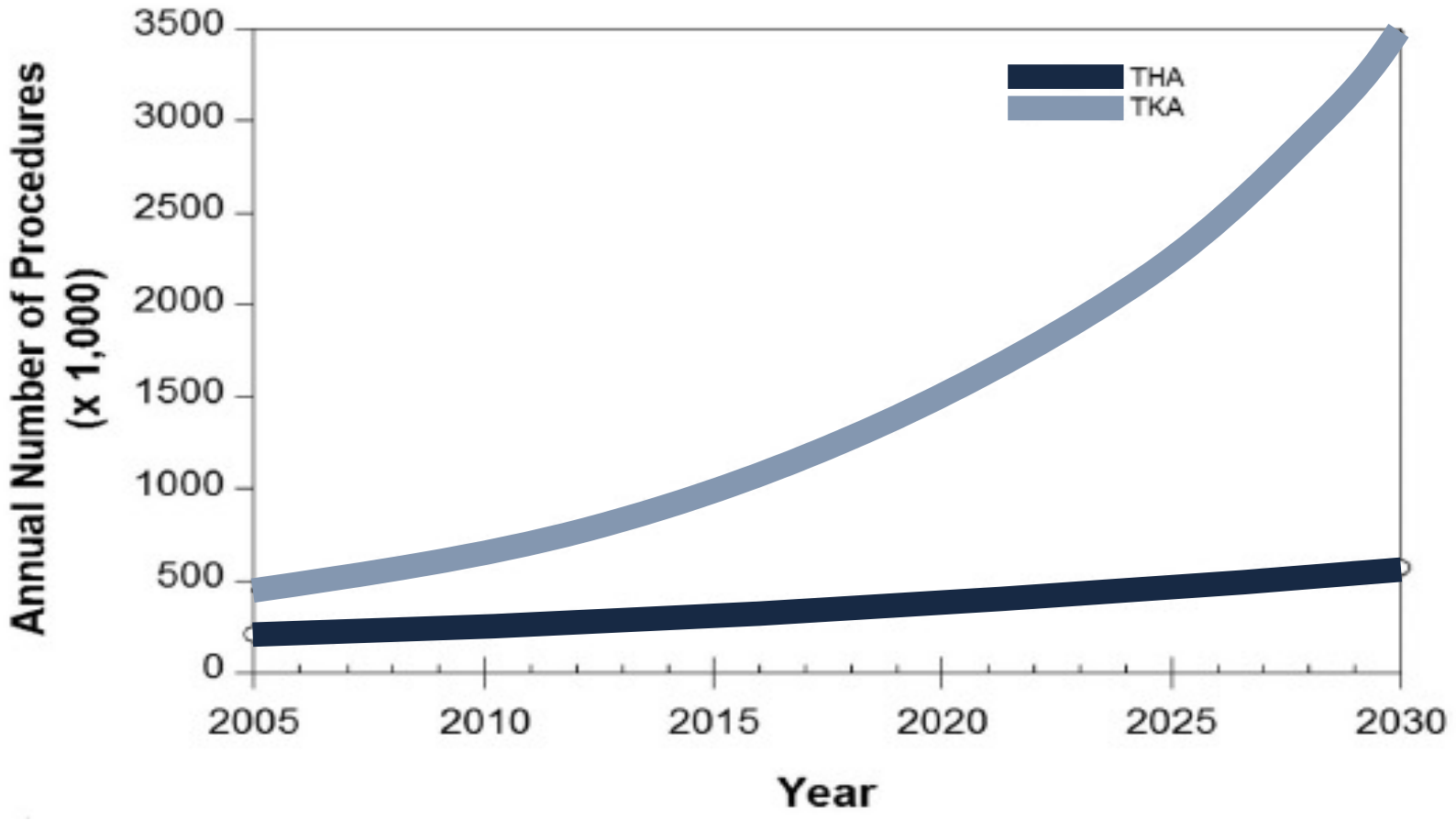
Predictably Improves Pain
Predictably Improves Function

Excellent long term outcomes

Cost Effective

Daigle ME, Weinstein AM, Katz JN, Losina E. The cost-effectiveness of total joint arthroplasty: A systematic review of published literature. Best Practice & Research Clinical Rheumatology 2012;26:649–58. doi:10.1016/j.berh.2012.07.013.
Waimann CA, Fernandez-Mazarambroz RJ, Cantor SB, Lopez-Olivo MA, Zhang H, Landon GC, et al. Cost-Effectiveness of Total Knee Replacement: A Prospective Cohort Study. Arthritis Care & Research 2014;66:592–9. doi:10.1002/acr.22186.
Scuderi GR, Insall JN, Windsor RE, and Moran MC: Survivorship of cemented knee replacements. J Bone Joint Surg Br 1989; 71: pp. 798-803

Demand



Kurtz S. Projections of Primary and Revision Hip and Knee Arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007.

The New York Times

Well

Knee Replacement May Be a Lifesaver for Some

By TARA PARKER-POPE FEBRUARY 27, 2012 5:49 PM 114

Stuart Bradford

By the time 64-year-old Laura Milson decided to undergo total knee replacement after 12 years of suffering from arthritis, even a short walk to the office printer was a struggle.

After her surgery last August at the Rothman Institute at Thomas Jefferson University in Philadelphia, Ms. Milson spent a week in rehabilitation and says she hasn't stopped walking since. "My son says to me, 'You have to slow down,' and I say, 'No, I have to catch up!,' " she said. "It's a whole different life."

For Ms. Milson, who lives in Shrewsbury, Pa., replacing the joint in her right knee came with a surprising bonus: a 20-pound weight loss in two months. "I joked with my doctor, 'I think you put a diet chip in my knee,' " she said. "The weight just sort of came off."

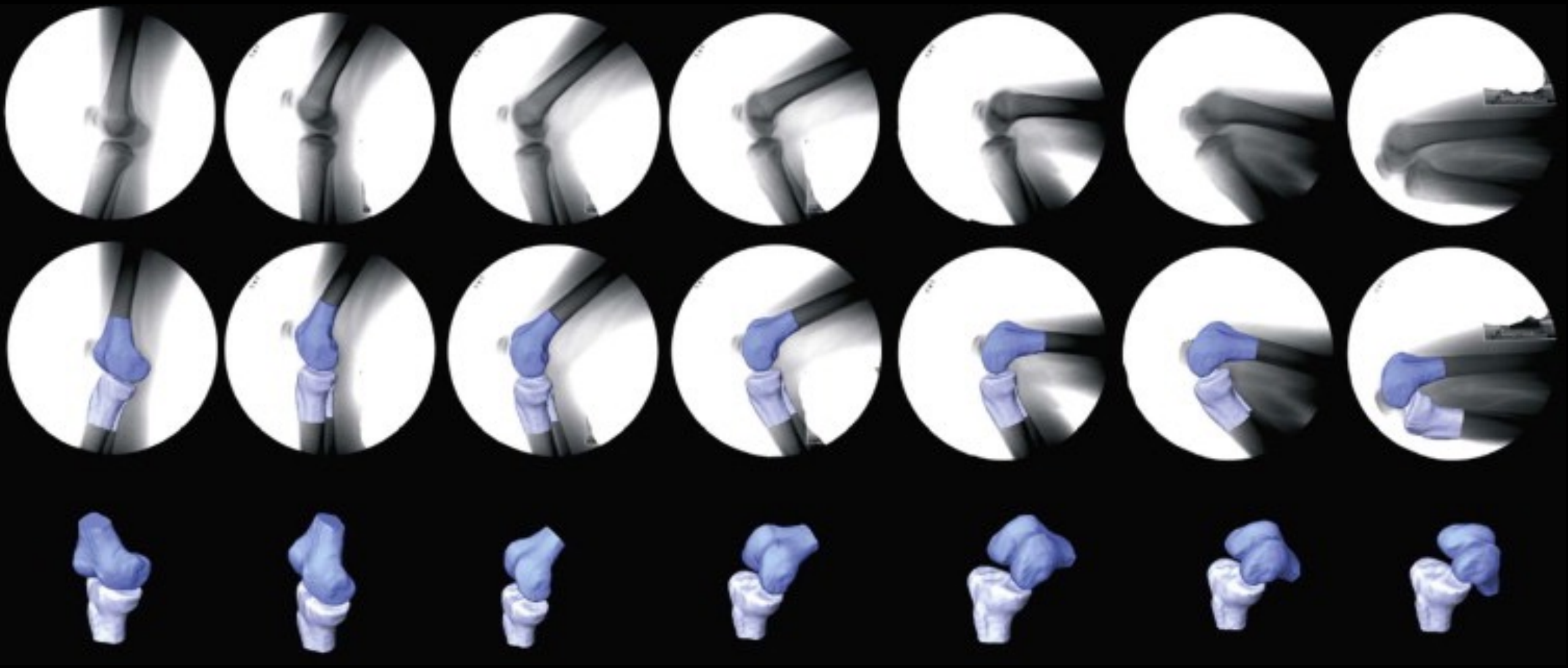
Now she has joined Weight Watchers to drop a few extra pounds and is training for a three-day breast cancer walk in October.

For years surgeons have boasted of the pain relief and improved quality of life that often follow knee replacement. But now new research suggests that for some patients, knee replacement surgery can actually save their lives.

In a sweeping study of Medicare records, researchers from Philadelphia and Menlo Park, Calif., examined the effects of joint replacement among nearly 135,000 patients with new diagnoses of osteoarthritis of the knee from 1997 to 2009. About 54,000 opted for knee replacement; 81,000 did not.

Three years after diagnosis, the knee replacement patients had an 11 percent lower risk of heart failure. And after seven years, their risk of dying for any reason was 50 percent lower.

The study, presented this month at the annual meeting of the American Academy of Orthopedic Surgeons, was financed with a grant from a knee replacement manufacturer. It was not randomized, so it may be that these patients were healthier and more active to start with.



Adrija Sharma, Richard Komistek, Insall & Scott Surgery of the Knee, 2012

Development

1860 Interposition of soft tissues

1860 Resection

1940 Metal femoral mold

1958 Hemiarthroplasty
(McKeever, MacIntosh)

1971 Cemented Arthroplasty
(Gunston, Freeman-Swanson)

POLYCENTRIC KNEE ARTHROPLASTY

Prosthetic Simulation of Normal Knee Movement

FRANK H. GUNSTON, WINNIPEG, CANADA

From the Centre for Hip Surgery, Wrightington Hospital, Lancashire, England

Movement in the normal knee joint follows a multiple centre or polycentric pathway. This paper will attempt to show the advantages of prosthetic simulation of normal knee movement for the difficult problem of the painful and unstable knee in rheumatoid polyarthritis. The biomechanical principles and experience gained from total hip replacement arthroplasty were combined with an analysis of normal knee movement to determine a solution.

NORMAL KNEE JOINT MOVEMENT

Movement in the normal knee is a complex movement composed of rocking, gliding and axial rotation (Fig. 1). Beginning at full extension, axial rotation of the femur about the tibia occurs during the initial 10 degrees of flexion. At 10 degrees of flexion the axial rotation converts to rocking movement in which the femoral condyles roll posteriorly on the tibial plateaus. The rocking movement changes to gliding motion at about 20 degrees of flexion, after which successive points on the femoral condyles slide forward on the tibial plateaus until full flexion is obtained.

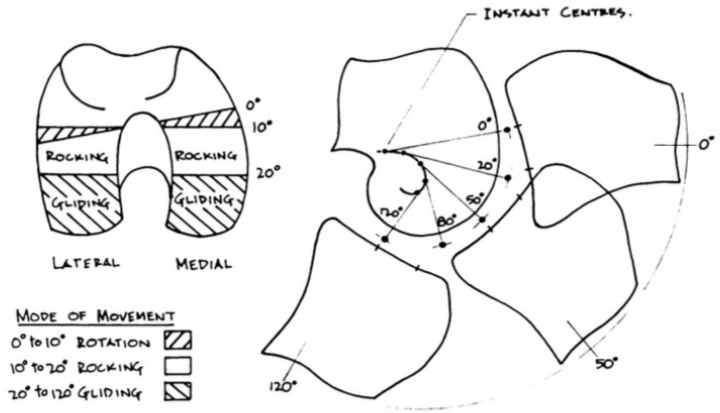
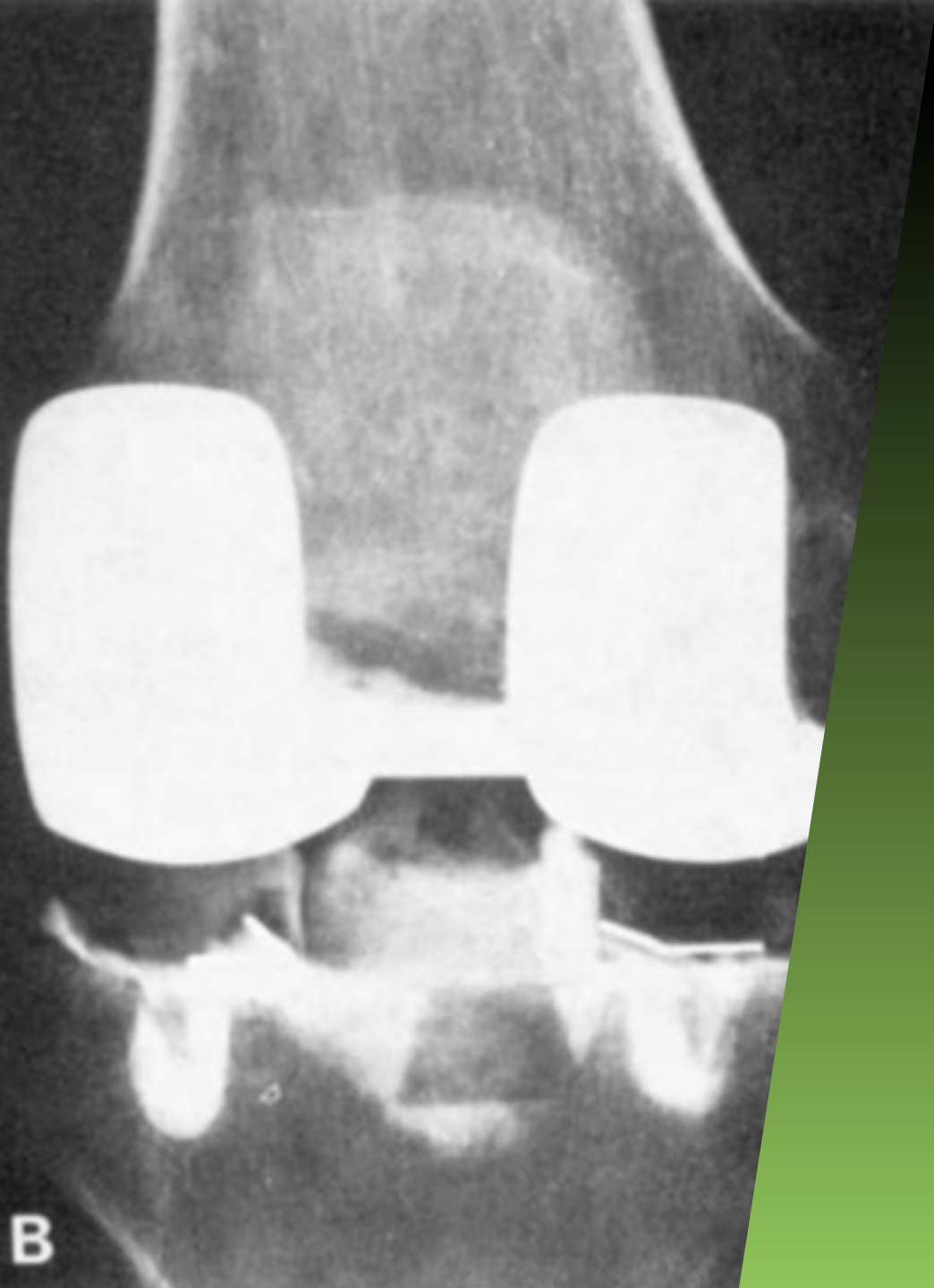
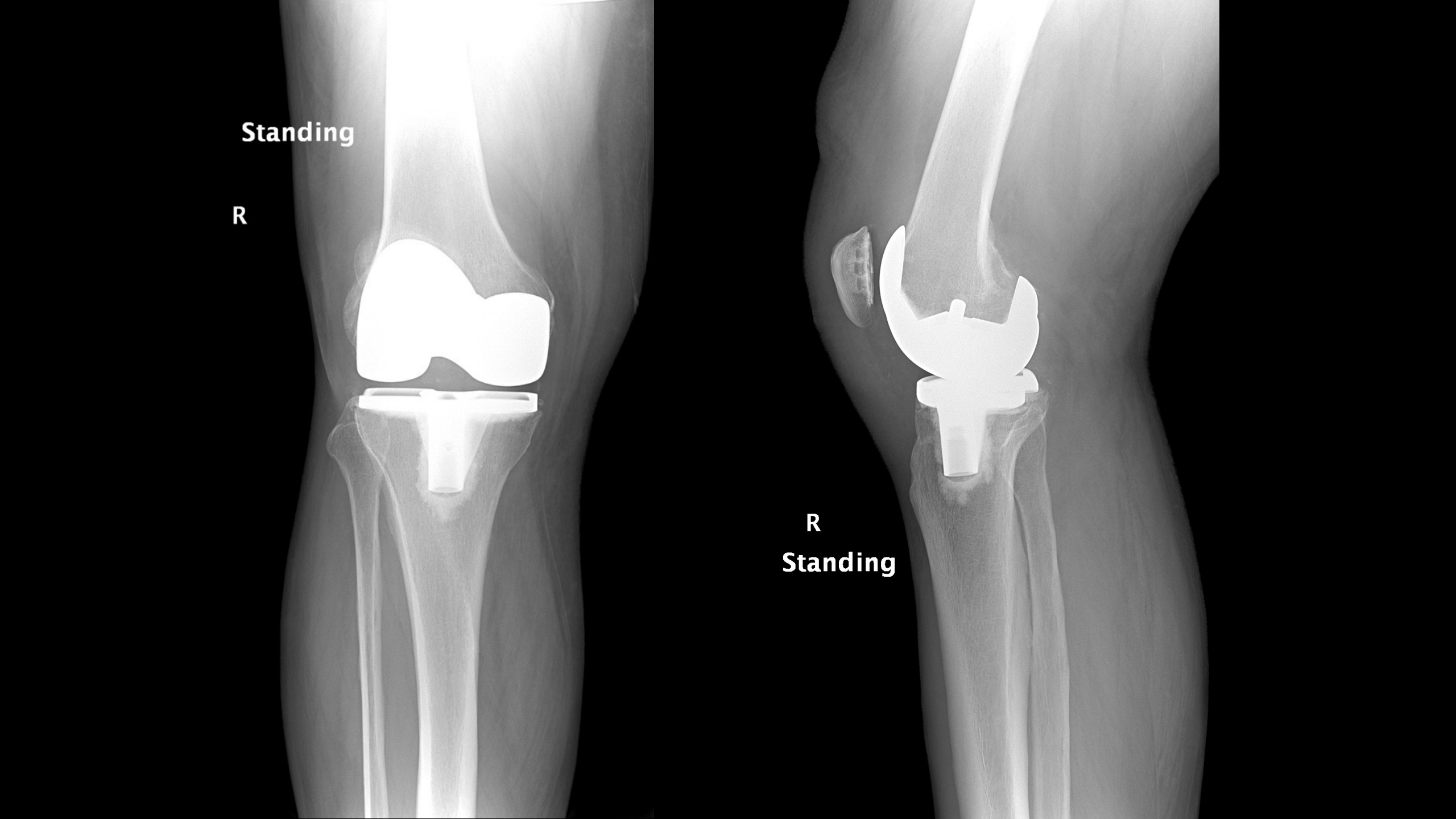


FIG. 1
Normal knee movement.

The instant centres determined for each increment of flexion move posteriorly in a spiral pattern (Fig. 1). These instant centres do not remain fixed in one position as would a simple hinge joint, but instead describe a multiple centre or polycentric pathway.



50 years later


Standing
R
R
Standing

Total Knee Replacement

Treatment for knee arthritis in multiple compartments

Modern implants & positioning come close to normal kinematics/function

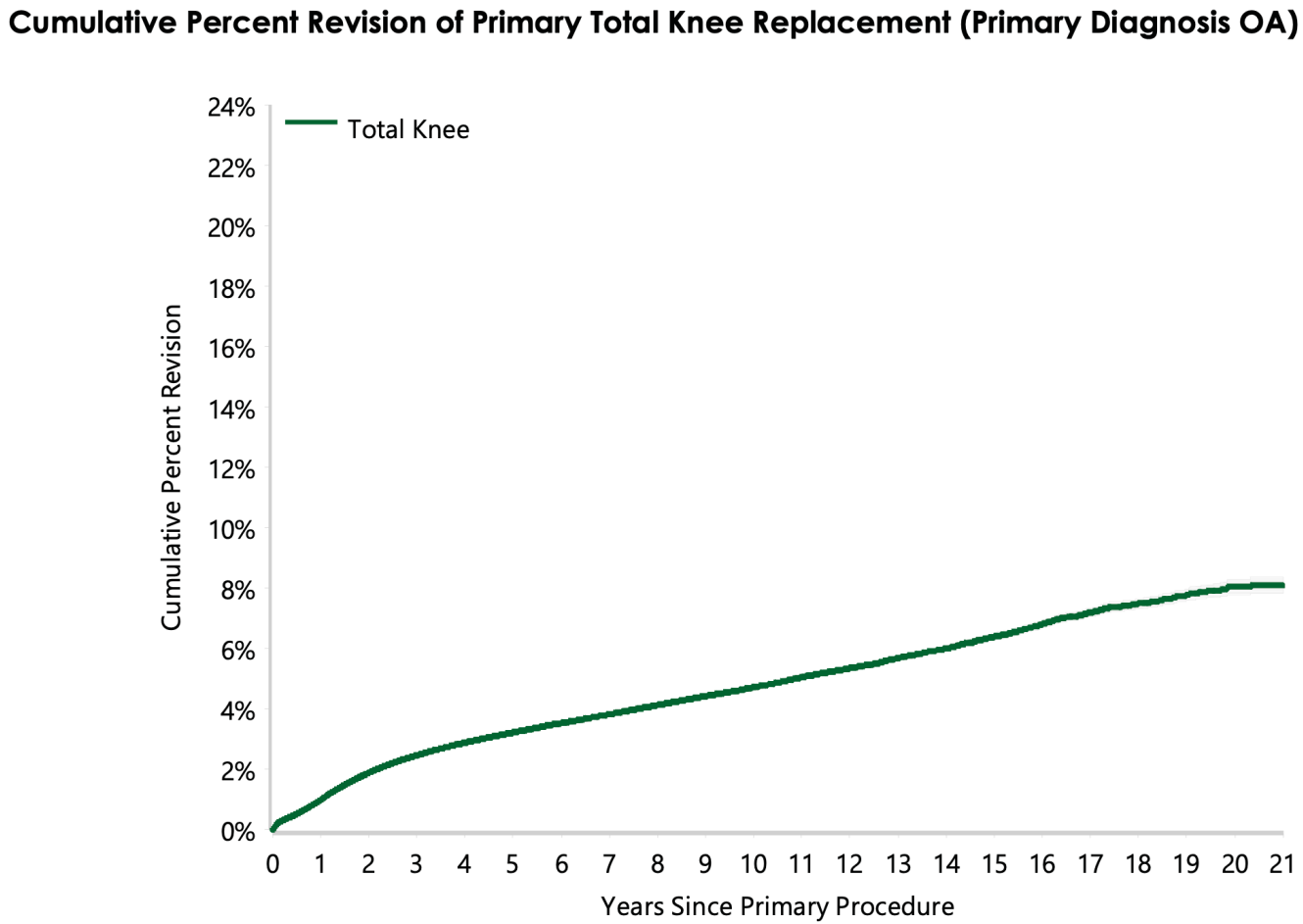
More durable

Less likely to require revision

Survivorship

8%

risk of revision at
20 years



27,372
Knee Replacements

1981 – 1995

83% satisfied with outcome

Dunbar MJ, Richardson G, Robertsson O. I can't get no satisfaction after my total knee replacement: rhymes and reasons. Bone Joint J. 2013 Nov.
Robertsson O, Dunbar M, Pehrsson T, Knutson K, Lidgren L. Patient satisfaction after knee arthroplasty: a report on 27,372 knees operated on between 1981 and 1995 in Sweden. Acta Orthop Scand 2000;71-3:262–267.

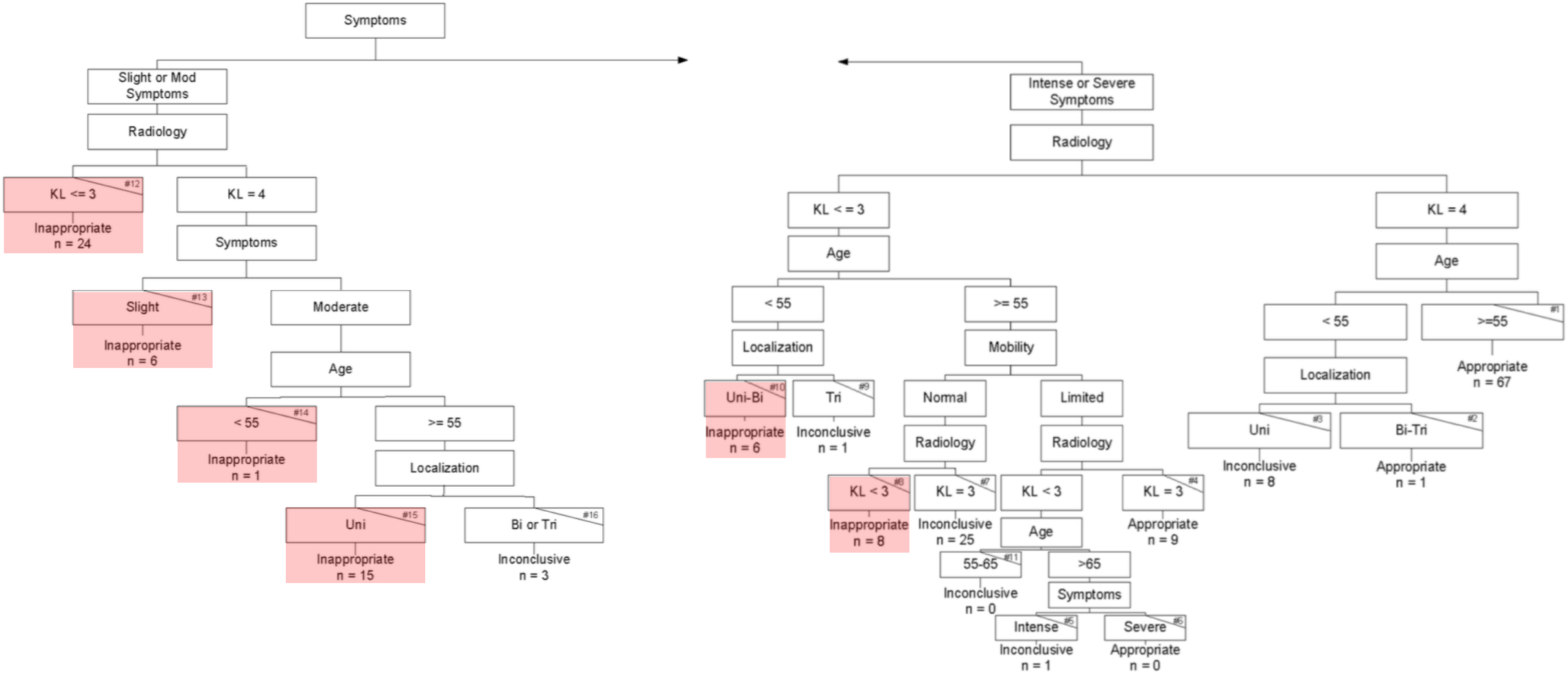
What
about the
other

17%?

Predictors Of Outcome

Diagnosis	Judge 2012
Radiographic classification	Jacobs 2014
Anxiety/depression	Judge 2012
Unmet expectations	Dunbar 2013
Severe functional impairment	Lavernia 2009
Race/ethnicity	Jacobs 2014, Lavernia 2011
Socioeconomic status	Judge 2012

Appropriateness



Riddle DL, Jiranek WA, Hayes CW. Use of a Validated Algorithm to Judge the Appropriateness of Total Knee Arthroplasty in the United States: A Multicenter Longitudinal Cohort Study. Arthritis & Rheumatology 2014;66:2134-43.

Volume

Significant association between **low surgeon volume** and higher rate of infection (0.26% - 2.8% higher), procedure time (165 min versus 135 min), longer length of stay (0.4 - 2.13 days longer), transfusion rate (13% versus 4%), and **worse patient outcomes**.

The role of surgeon volume on patient outcome in total knee arthroplasty: a systematic review of the literature. Lau. BMC 2012

Alignment

The Goal

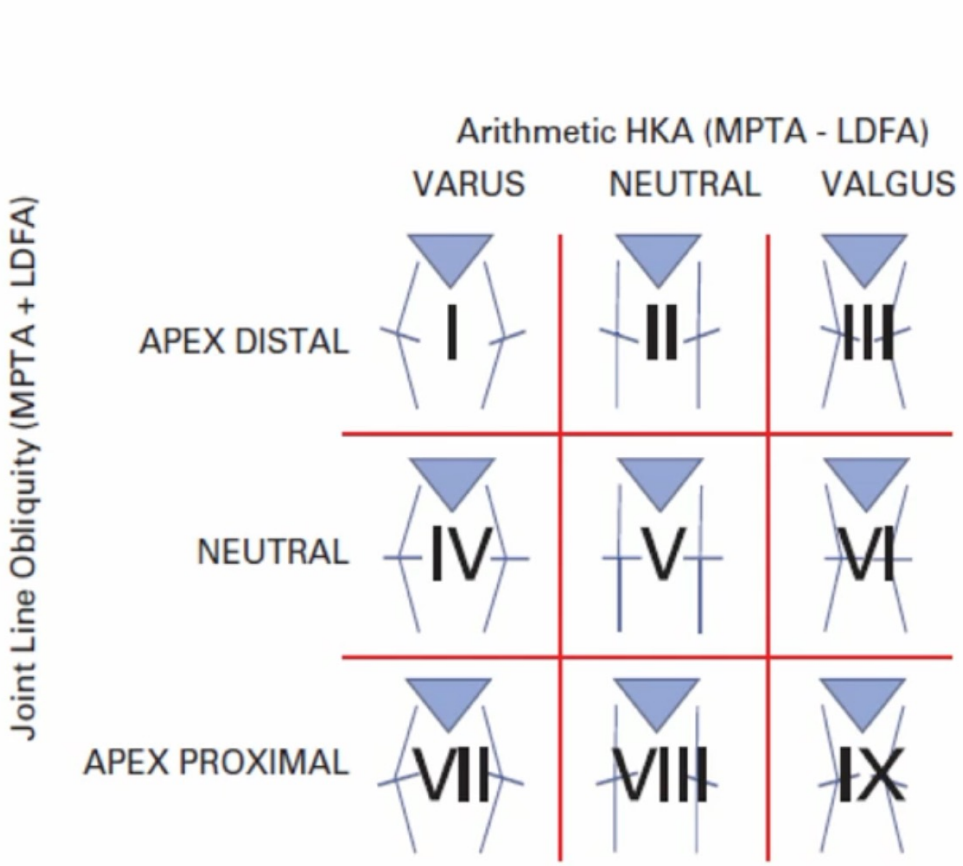
The goal **was** initially pain relief and longevity/durability.
The goal **now** is full function, satisfaction & a forgotten knee.

Alignment and implant positioning are key.
Preserving the joint line and MCL isometry are the key.

Knees Come in All Shapes and Sizes

CPAK classification

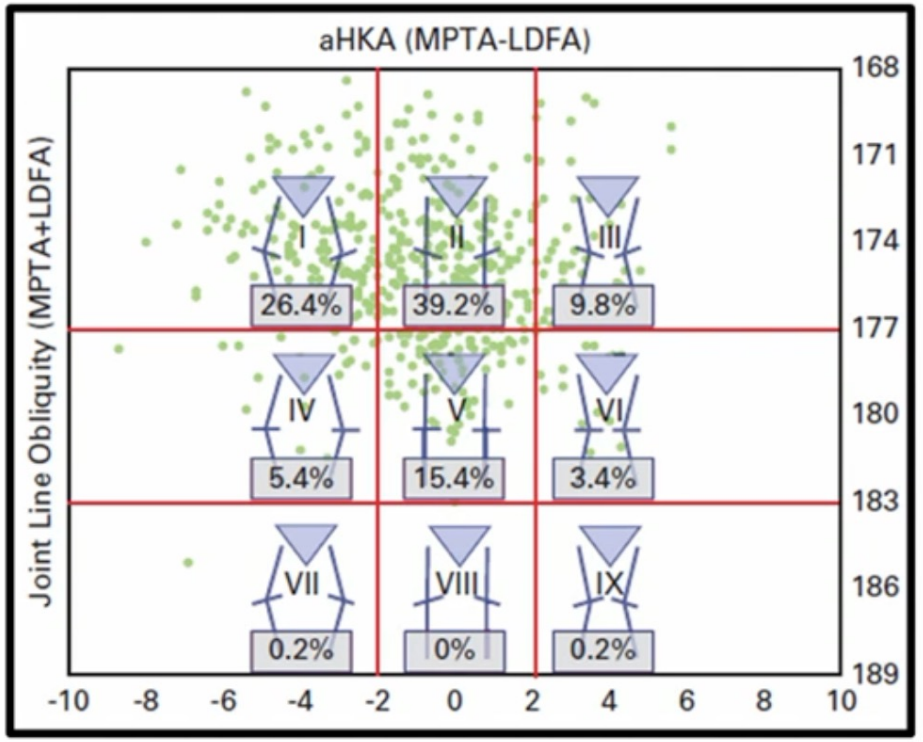
Combines limb alignment
& joint line obliquity



Distribution

II: **most common** neutral alignment varus joint line

I: 2nd most common varus alignment



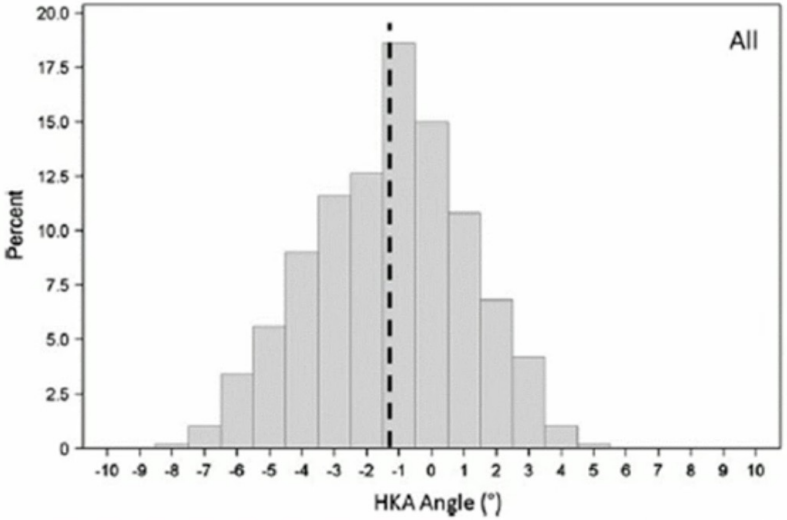
Constitutional Varus

Is Neutral Mechanical Alignment Normal for All Patients?

The Concept of Constitutional Varus

Johan Bellemans MD PhD, William Colyn MD,
Hilde Vendenneucker MD, Jan Victor MD PhD

CORR 2012

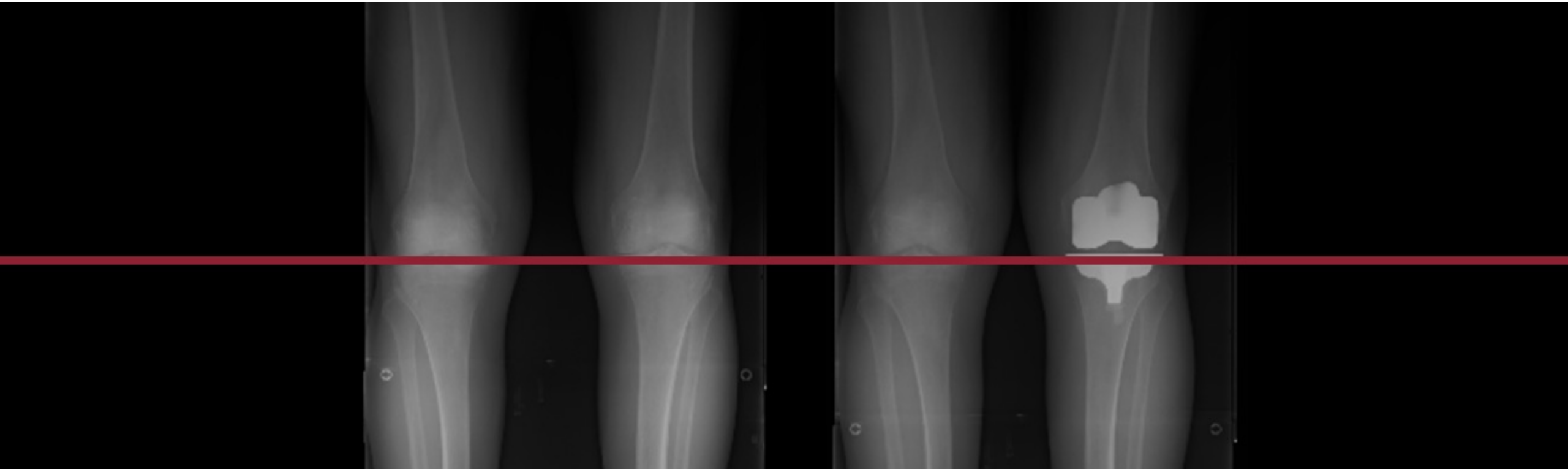


AAHKS
AMERICAN ASSOCIATION OF HIP AND KNEE SURGEONS

Ranawat Best Paper Award Recipent

Joint Line Obliquity

The human body favors a tibial plateau that is horizonal to the floor at heel strike.



Strategies

Fixed

Consistent target for every knee

Individualized

Prioritize native soft tissue balance

Novel Strategies

The goal of alternative alignment and position targets is to achieve a TKA which is:

- Well fixed
- Well balanced
- Meets expectations

- **Durable**

Mechanical Alignment

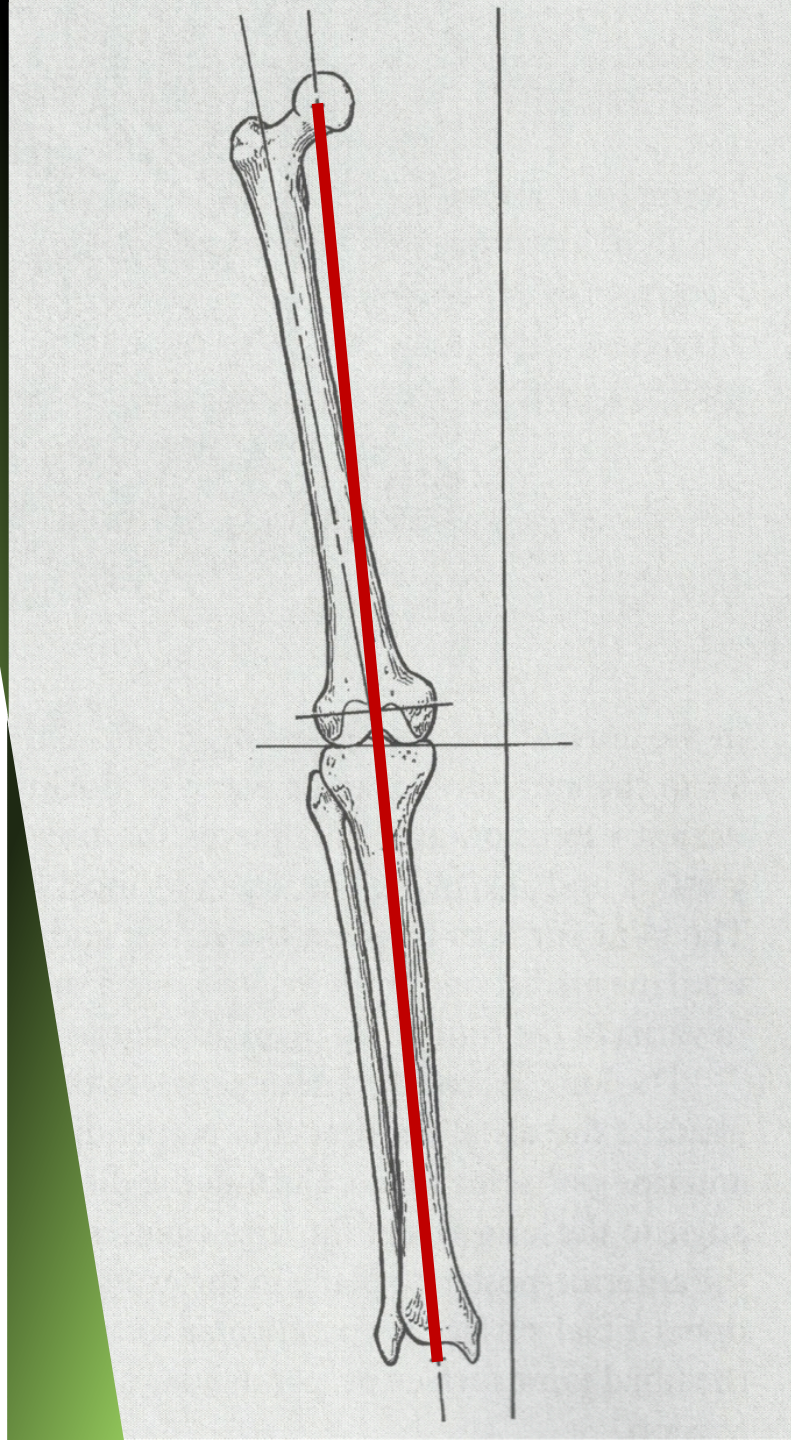
Gold standard

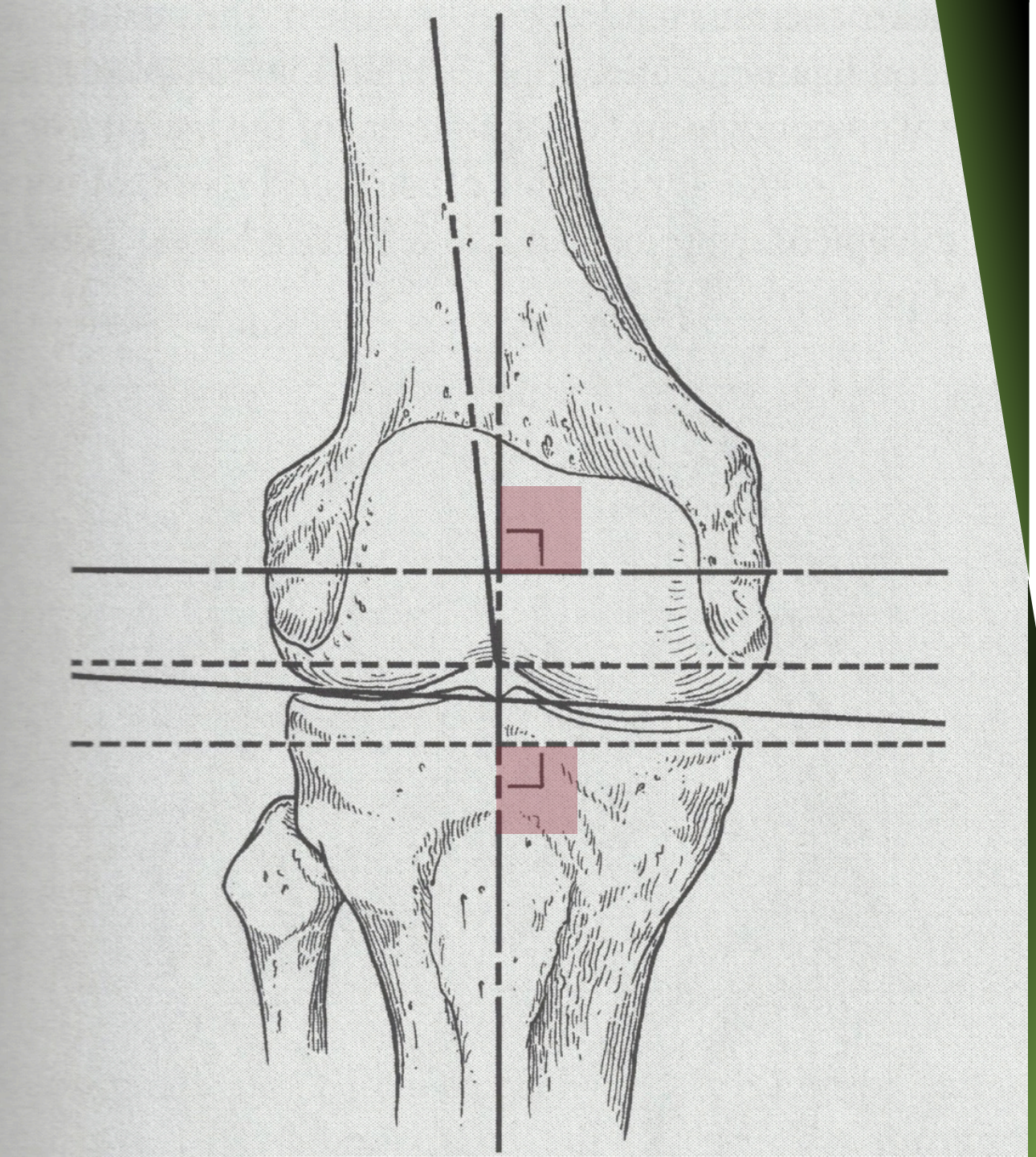
Last 40 years of TKA results

Aligns the femoral and tibial components **perpendicular to the mechanical axis** of each bone segment.

Achieves neutral HKA

Center of hip, knee and ankle are in a straight line.





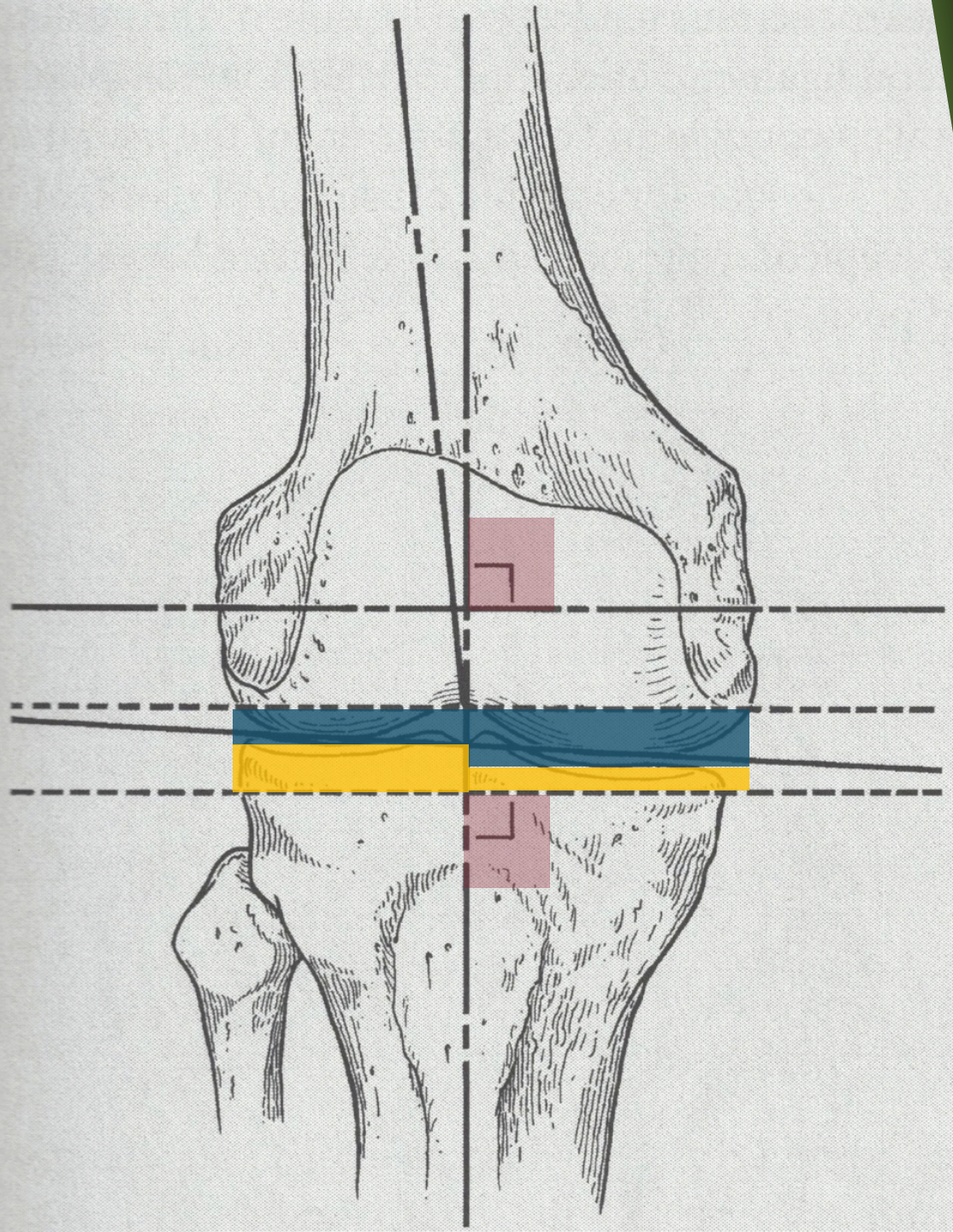
Mechanical Resections

Femoral resection

perpendicular to mechanical axis

Tibial resection

perpendicular to mechanical axis



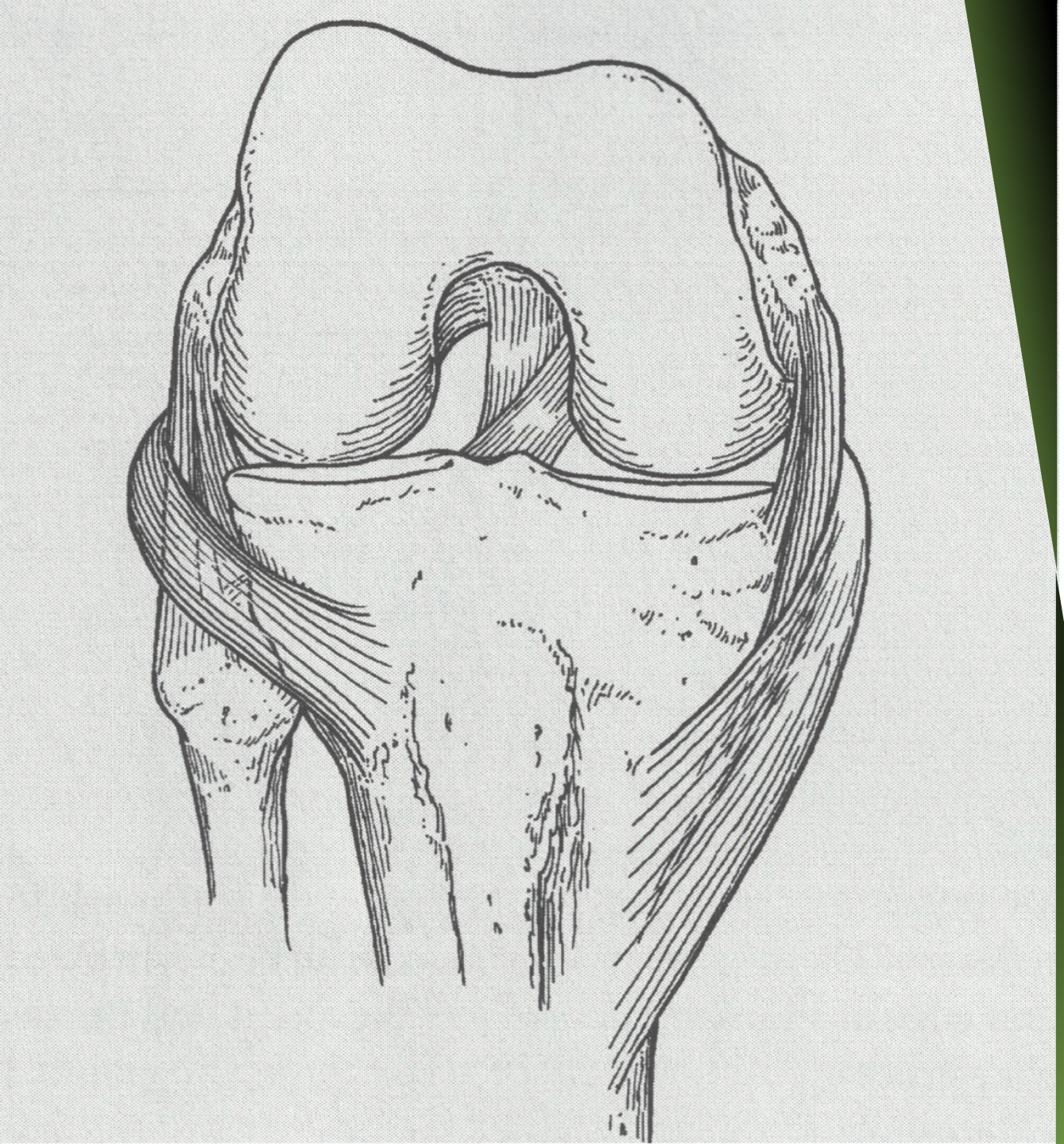
Mechanical Resections

Asymmetric bone cuts

(different from patient anatomy)

Intentionally ignored individual variation in alignment, morphology and biomechanics

Was designed to
optimize survivorship



Releases

Medial stabilizers in flexion

Deep MCL

Superficial MCL

Lateral stabilizers in flexion

LCL

Popliteus

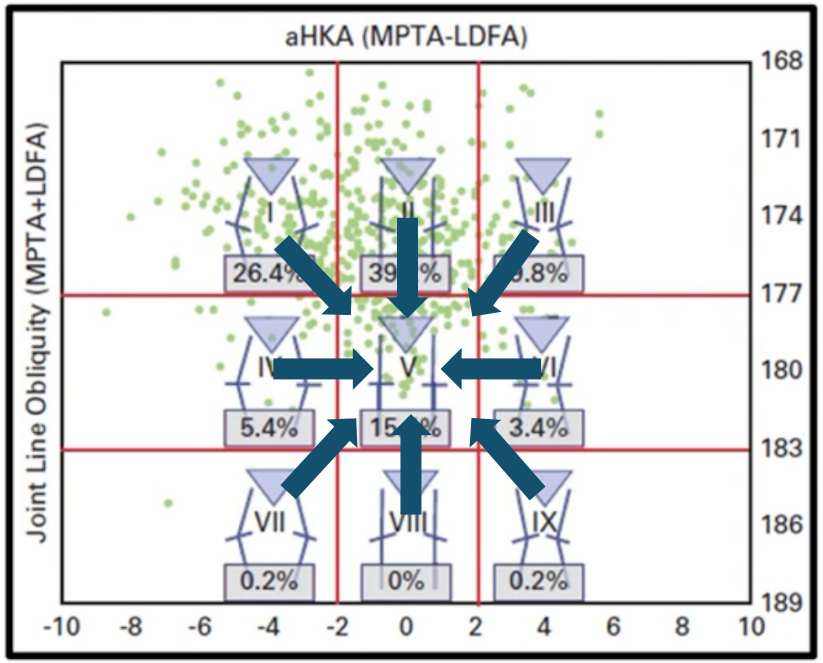
Parallel to joint in flexion

Pes anserinus

IT Band

Mechanical Alignment

V: **always the right answer**
neutral alignment
perpendicular joint line



Mechanical Alignment

- Over resect tibia laterally in flexion and extension
  - Artificially loosen medial side
  - Externally rotated femoral component
  - Over resect the posteromedial femur
  - Raises the medial joint line
- Does not restore joint line obliquity

Mechanical Alignment

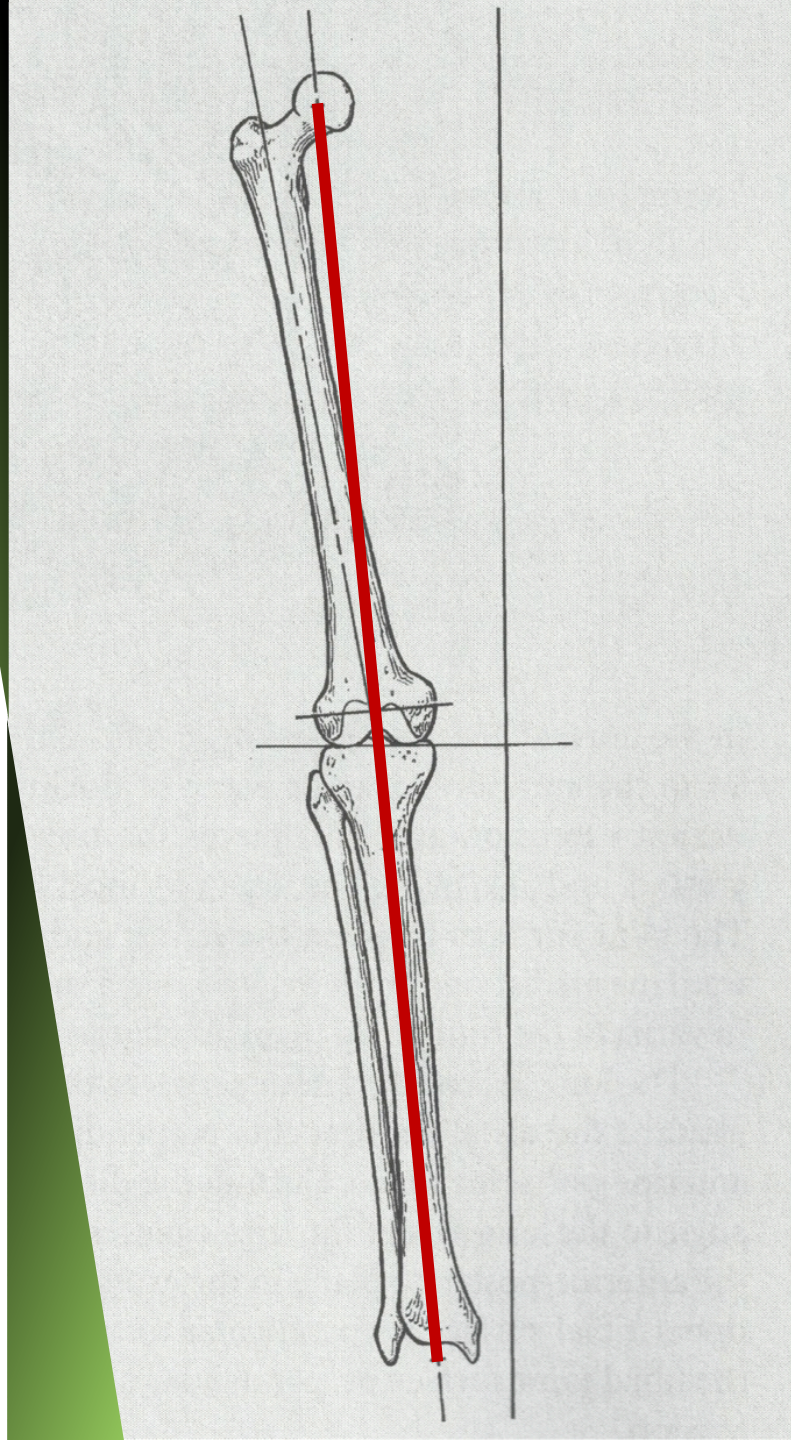
Constitutional varus	**NO**
Joint line obliquity	**NO**
Well balanced	**NO**
Well aligned	**YES**
Reproduceable	**YES**

Anatomic Alignment

Early precursor to individualized alignment.

Aligns the femoral and tibial components **based on anatomic axis**.

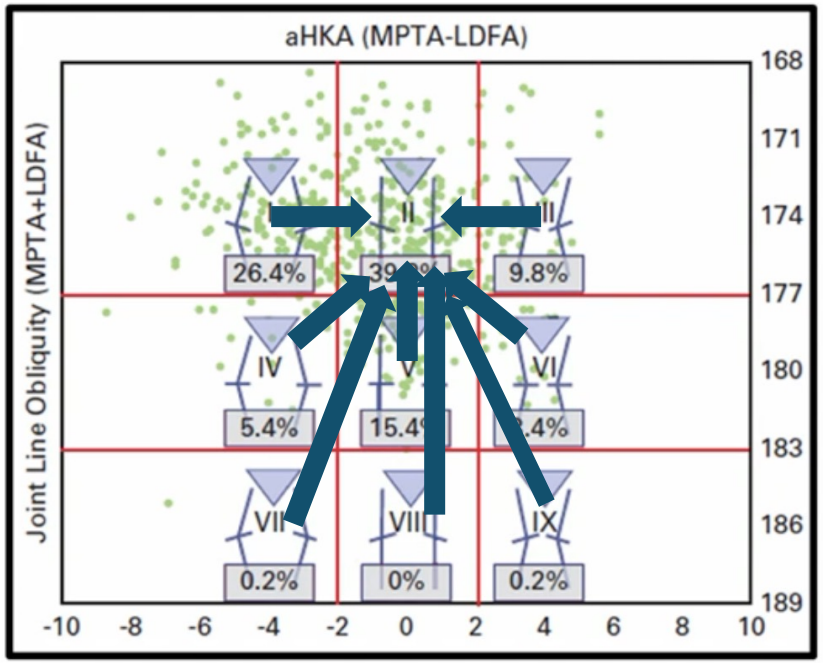
Achieves neutral HKA in some cases.



Anatomic Alignment

II: **always the right answer**
neutral alignment
varus joint line

Never gained much traction because it only made sense for a subset of cases



Anatomic Alignment

Constitutional varus	**NO**
Joint line obliquity	**YES**
Well balanced	**NO**
Well aligned	**MAYBE**
Reproduceable	**MAYBE**

Kinematic Alignment

Prosthetic resurfacing of cartilage and bone accounting for loss

Recreates normal anatomy
Ignores limb axes
No soft tissue releases

Kinematic Axis

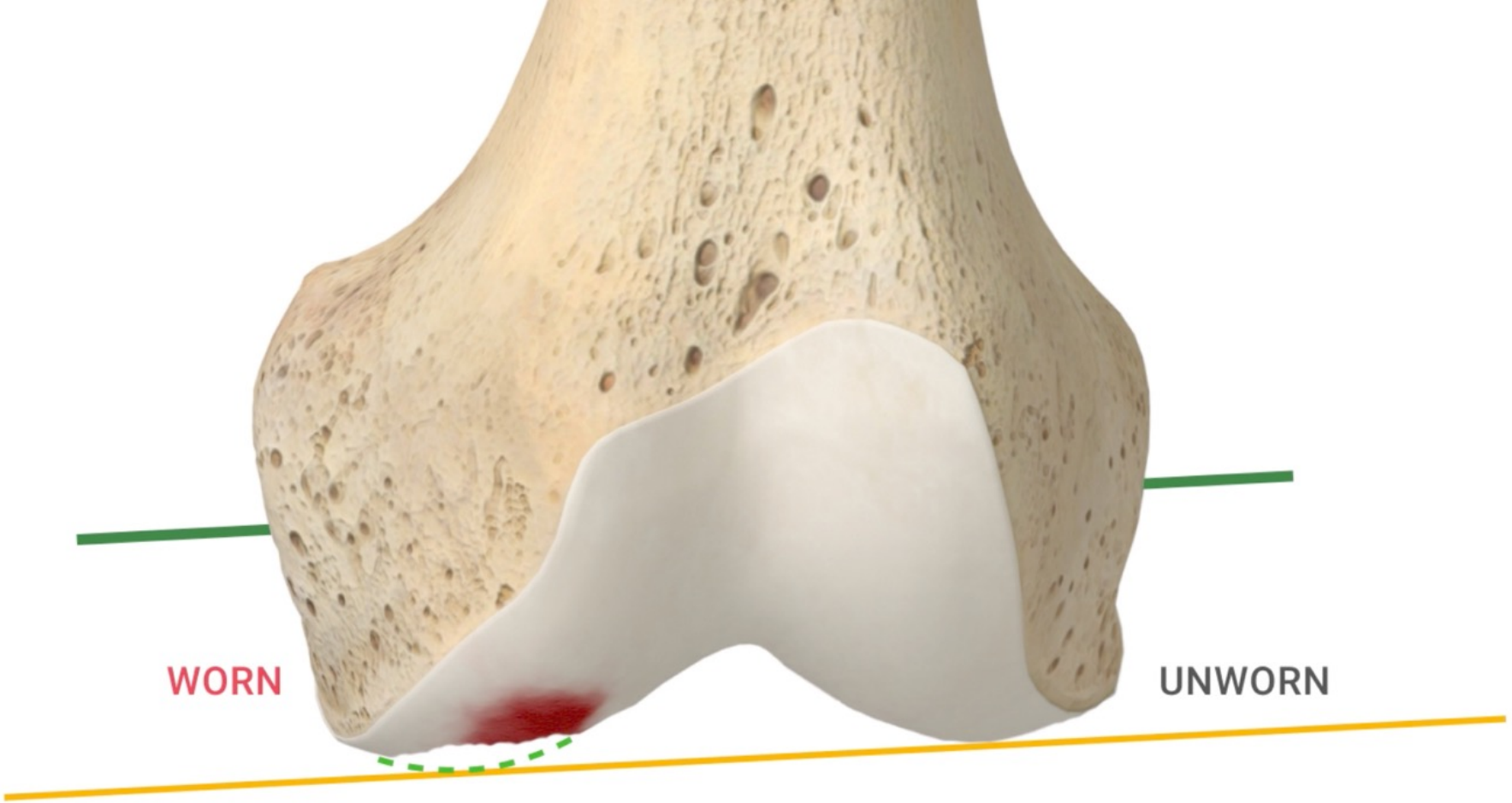
Kinematic Axis

Parallel to the joint lines

in extension

Parallel to the joint lines

and flexion

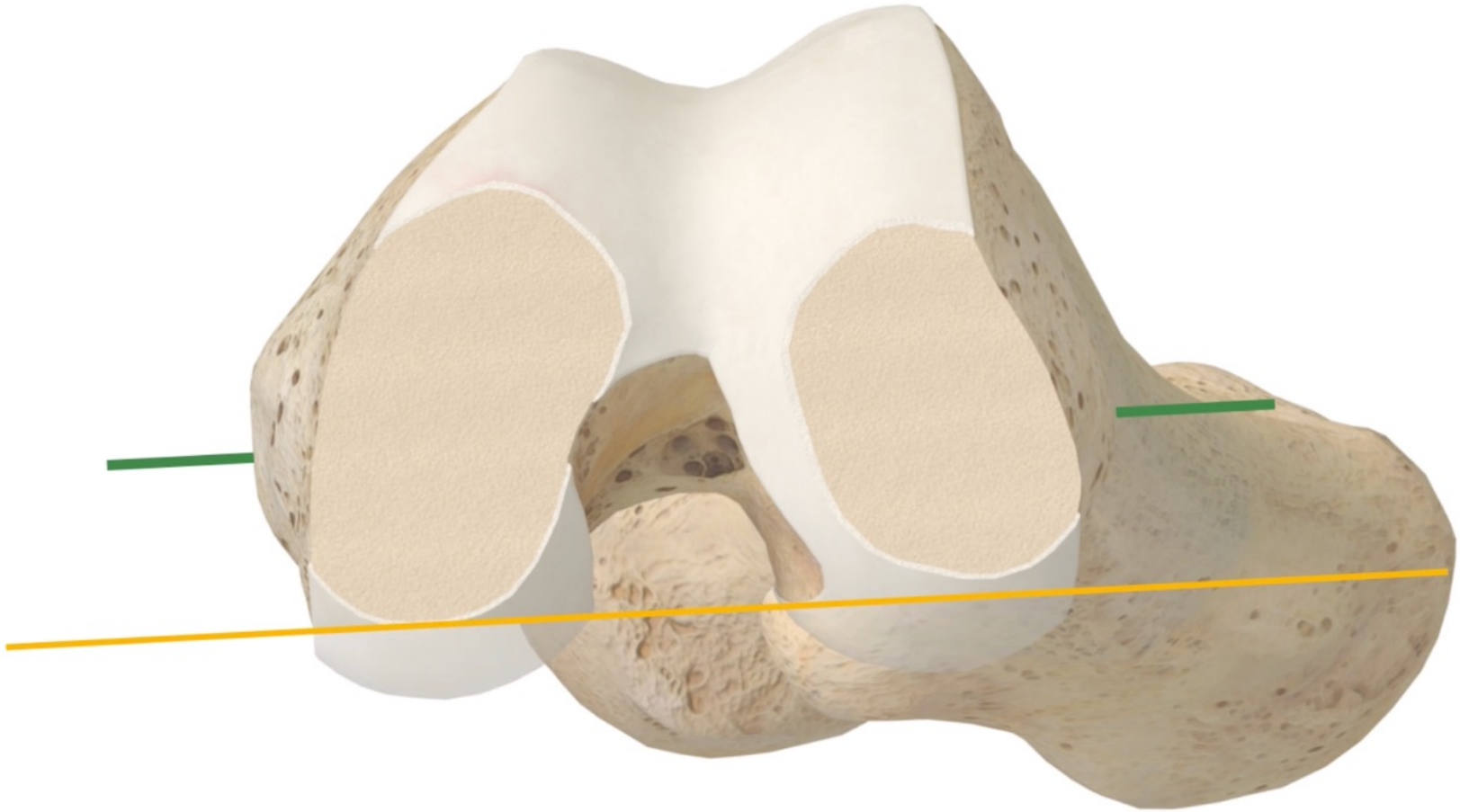


Resections based on unworn anatomy

to restore healthy joint state

Resection based on implant thickness

accounting for cartilage (and bone) loss



Resection based on implant thickness

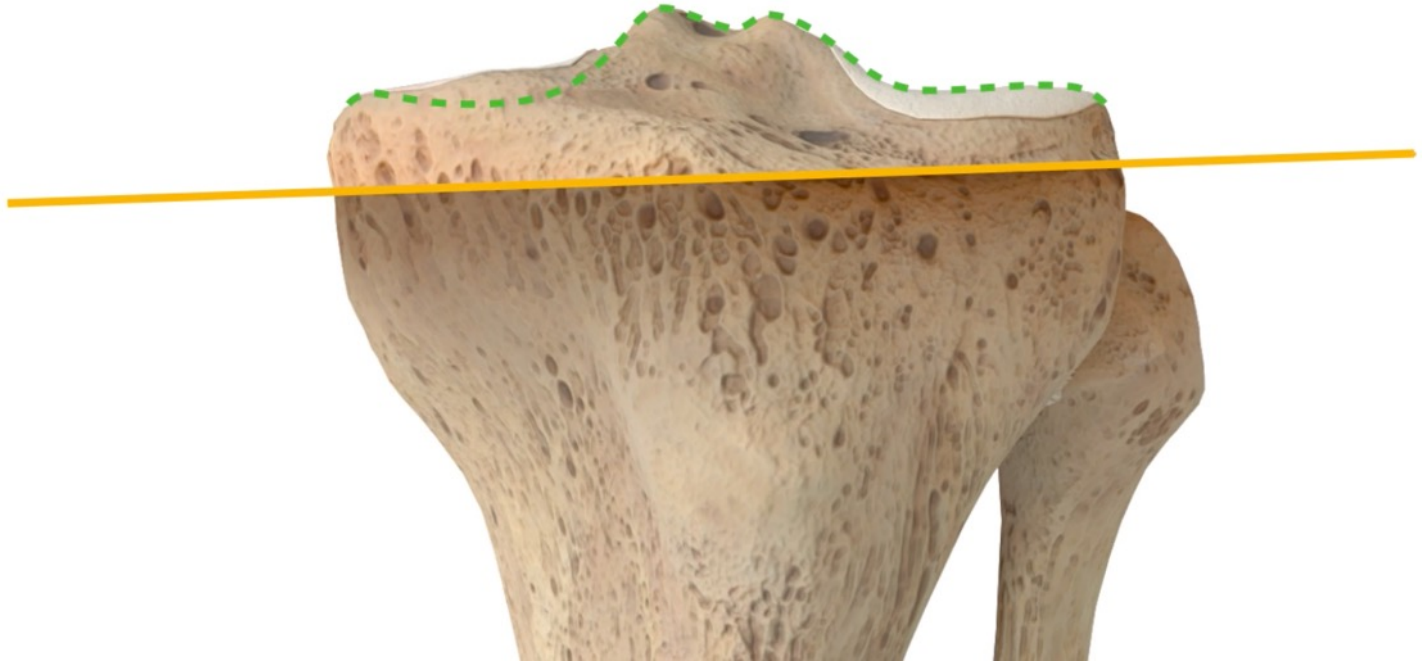
accounting for cartilage (and bone) loss

Resurface femur

and assess the stability and motion of the knee and tibia

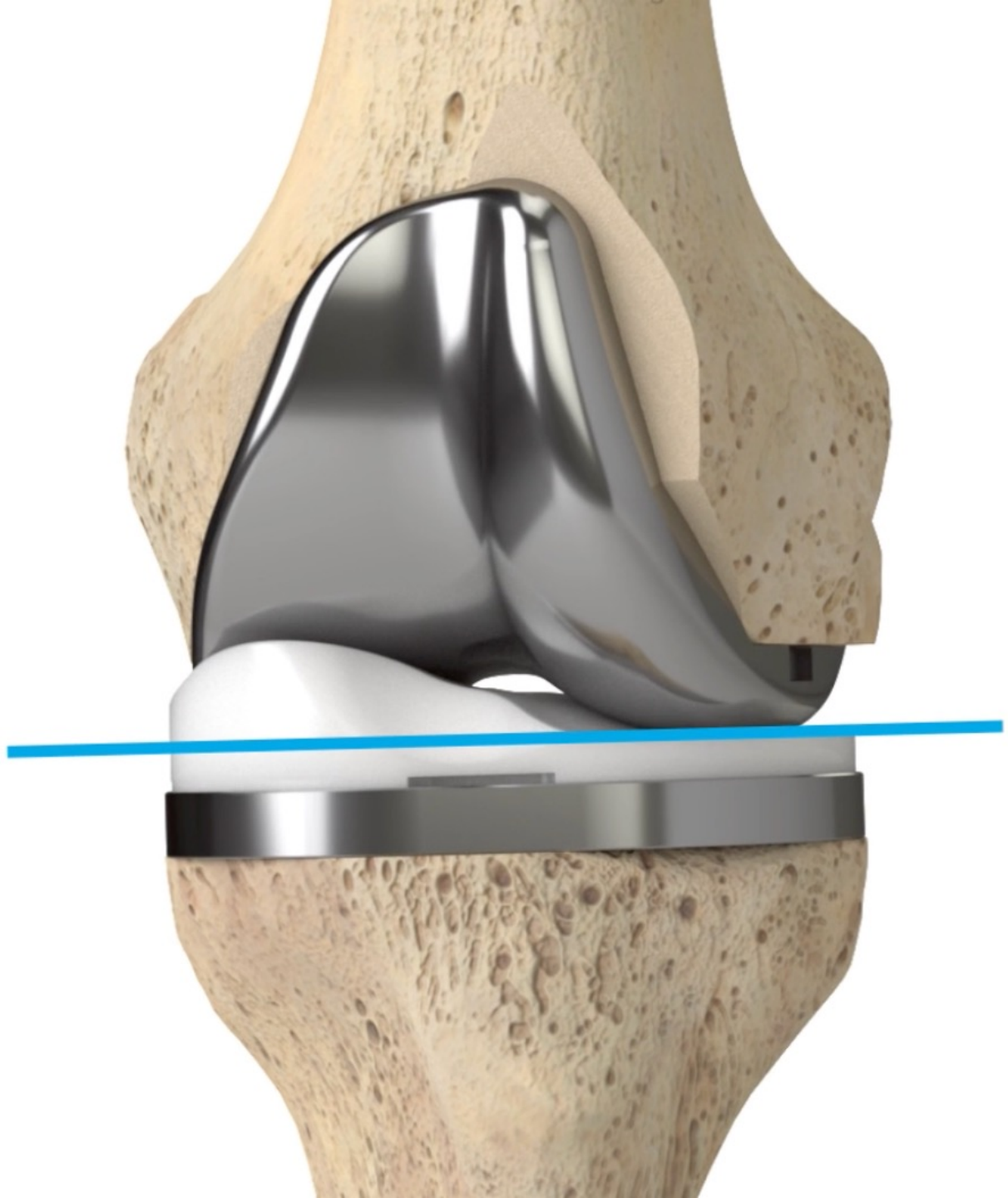
Tibial resection

Equal bone thickness medial and lateral



Knee resurfacing

Recreate joint lines
Restore kinematics
Restore pre-arthritic alignment



Technique

- More reproducible
  - Measure from bone surfaces instead of axes
  - Measure resected bone to match
  - Resurfacing operation
  - No change from pre-arthritic limb alignment

Survivorship

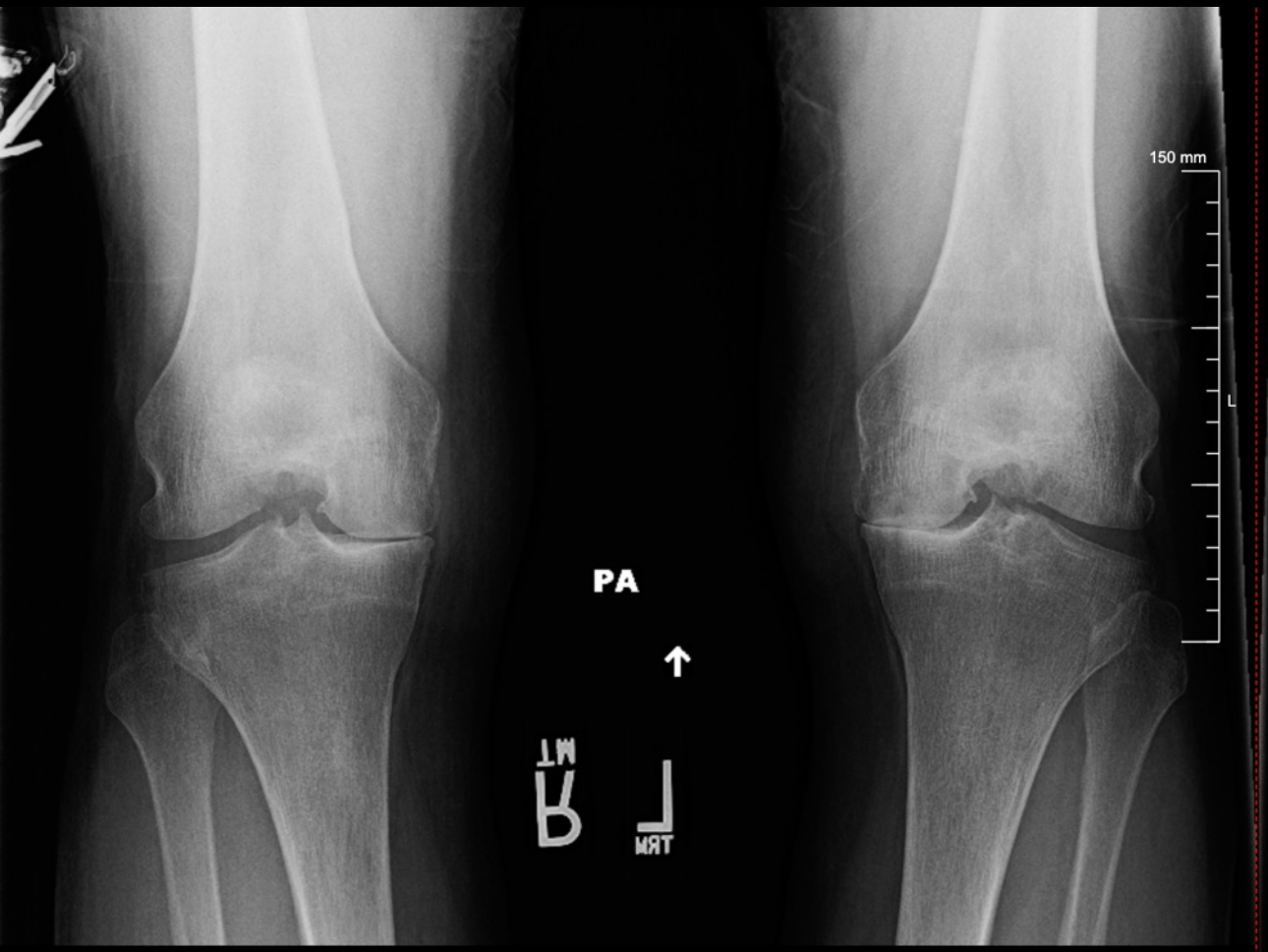
Randomized control studies show the survivorship with modern implants to be the same.

H. Dossett. A randomized controlled trial of knematically and mechanically aligned knee replacements.

Outcomes

- 2.4 times more likely to be pain free at 2 years.
- Improved range of motion.
- Improved oxford knee scores.

H. Dossett. A randomized controlled trial of knematically and mechanically aligned knee replacements.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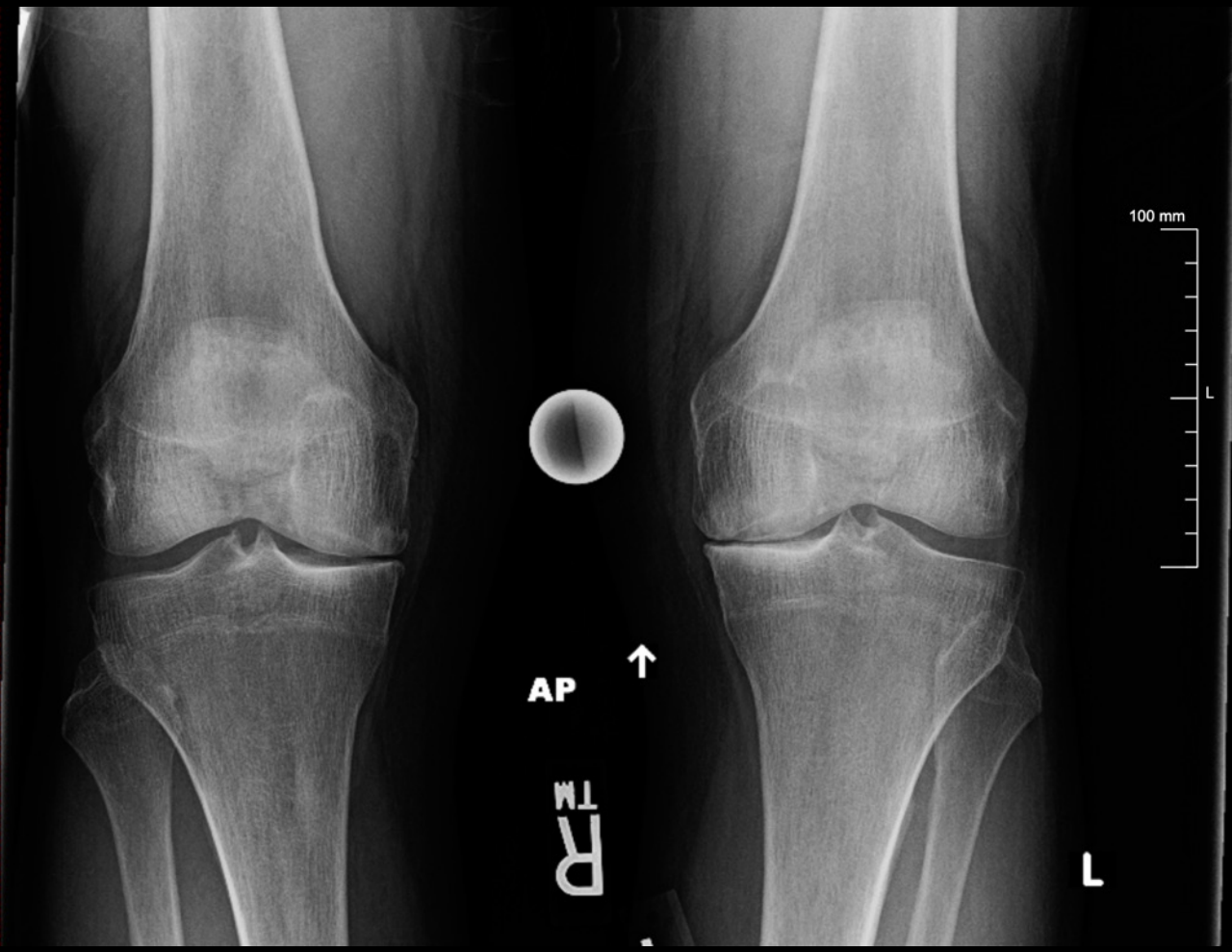
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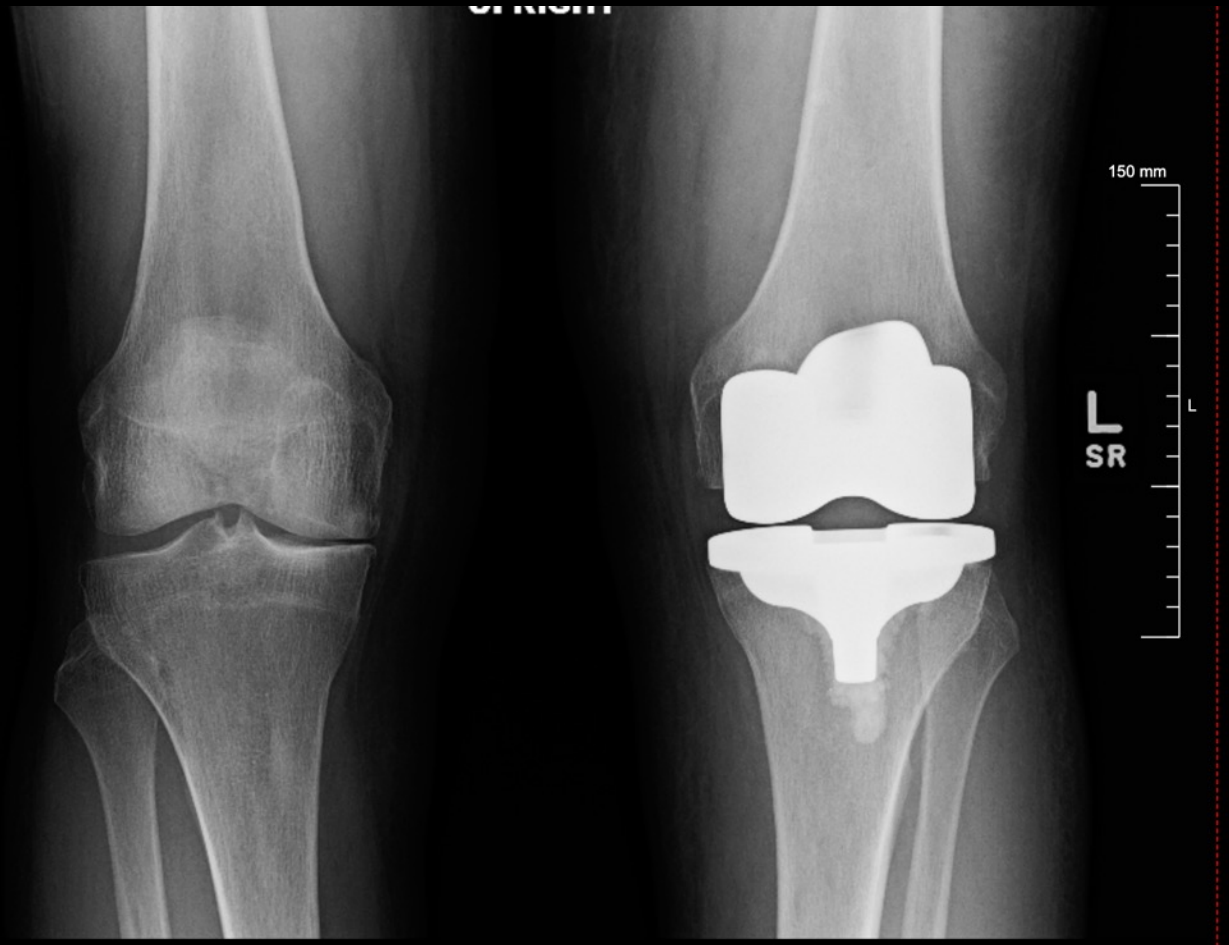
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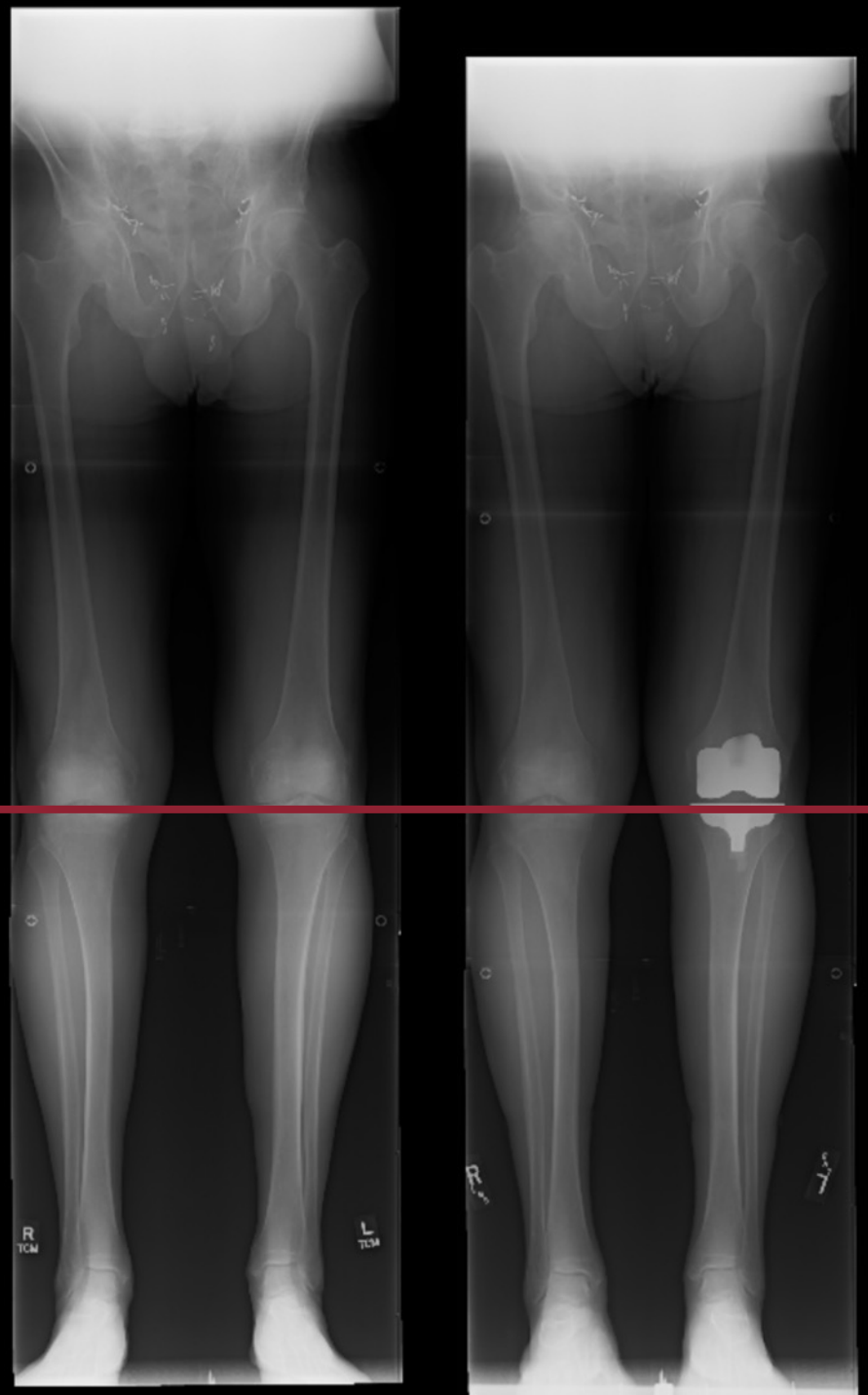
SR


150 mm
SR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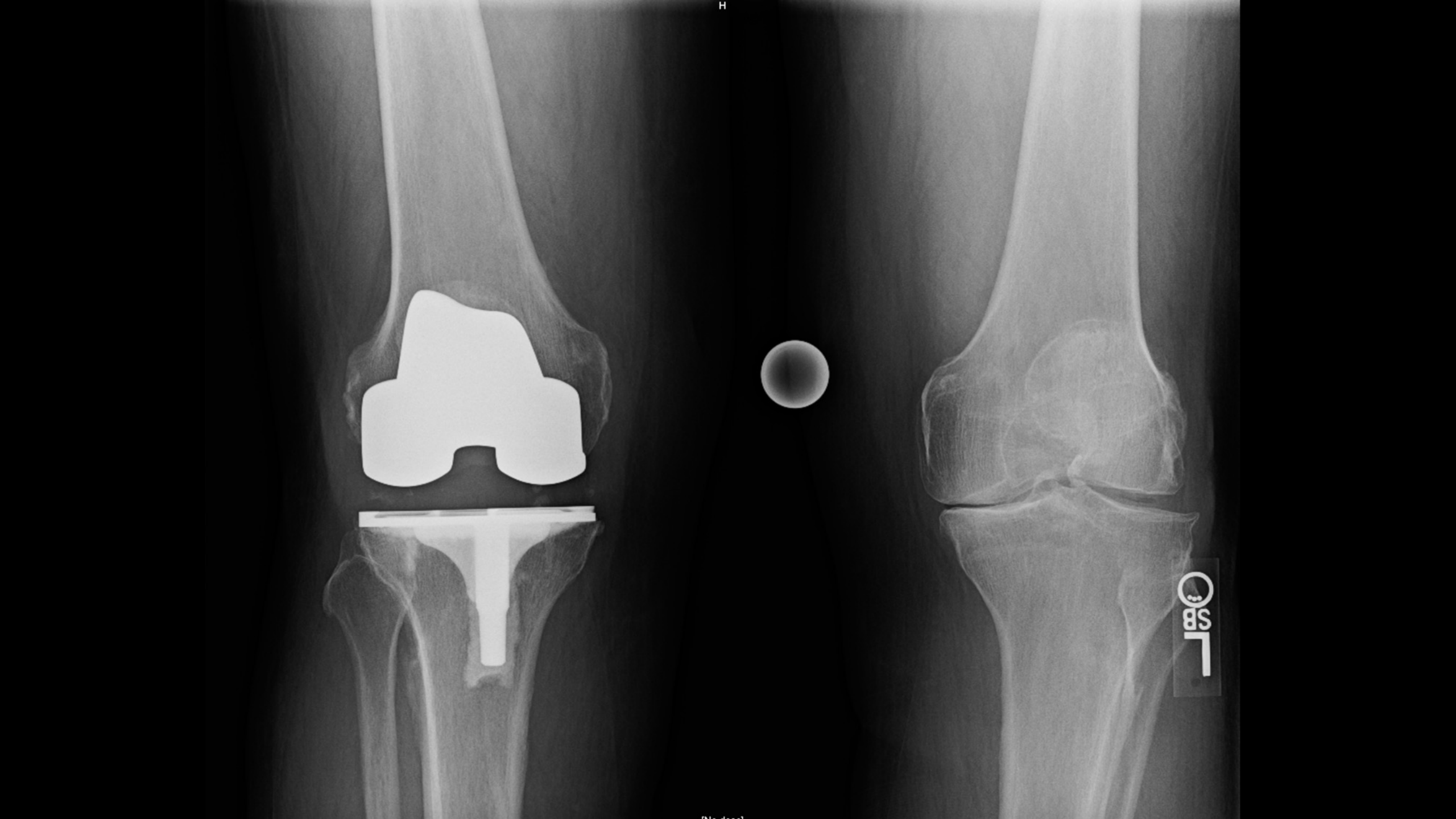
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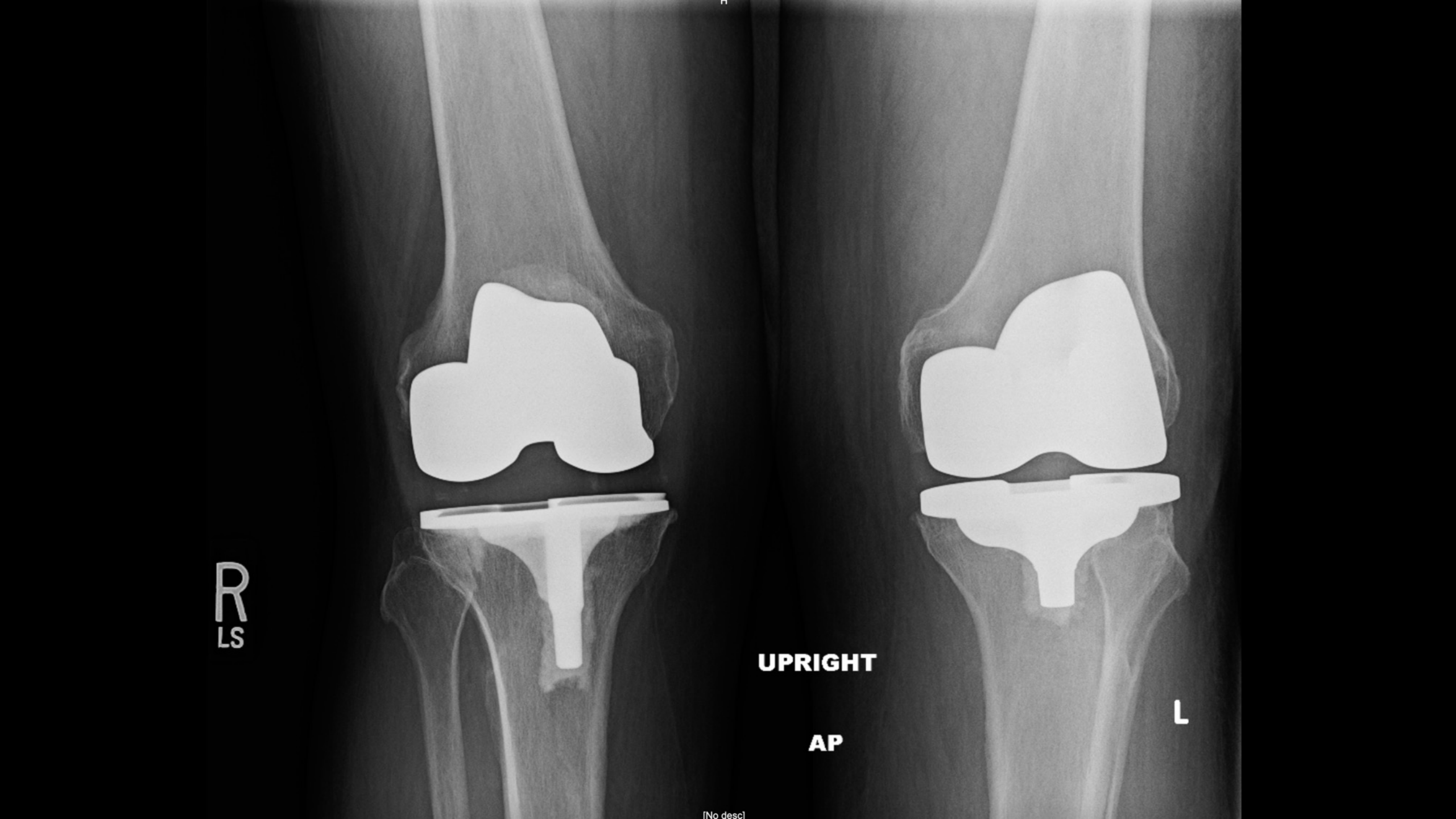
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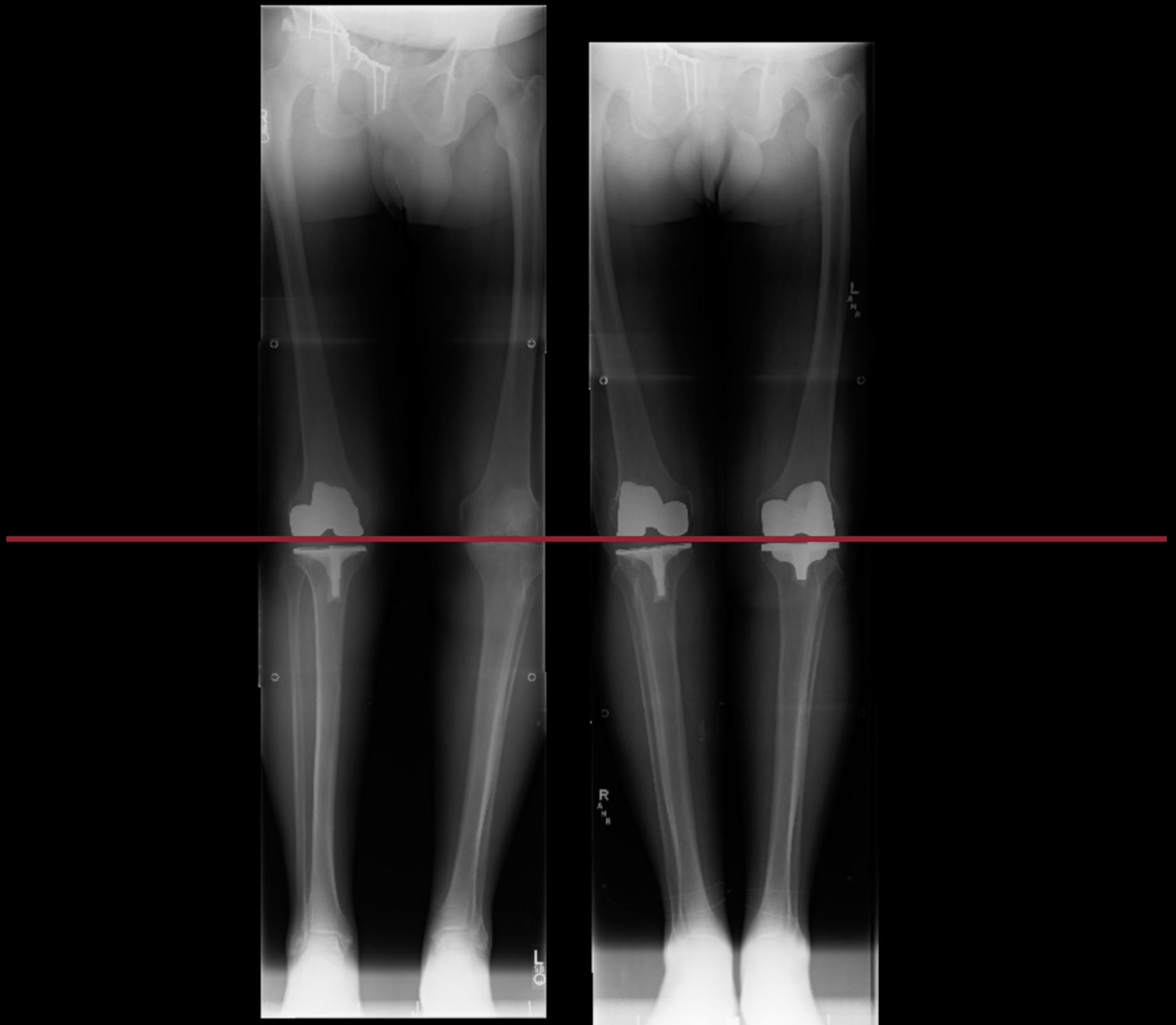
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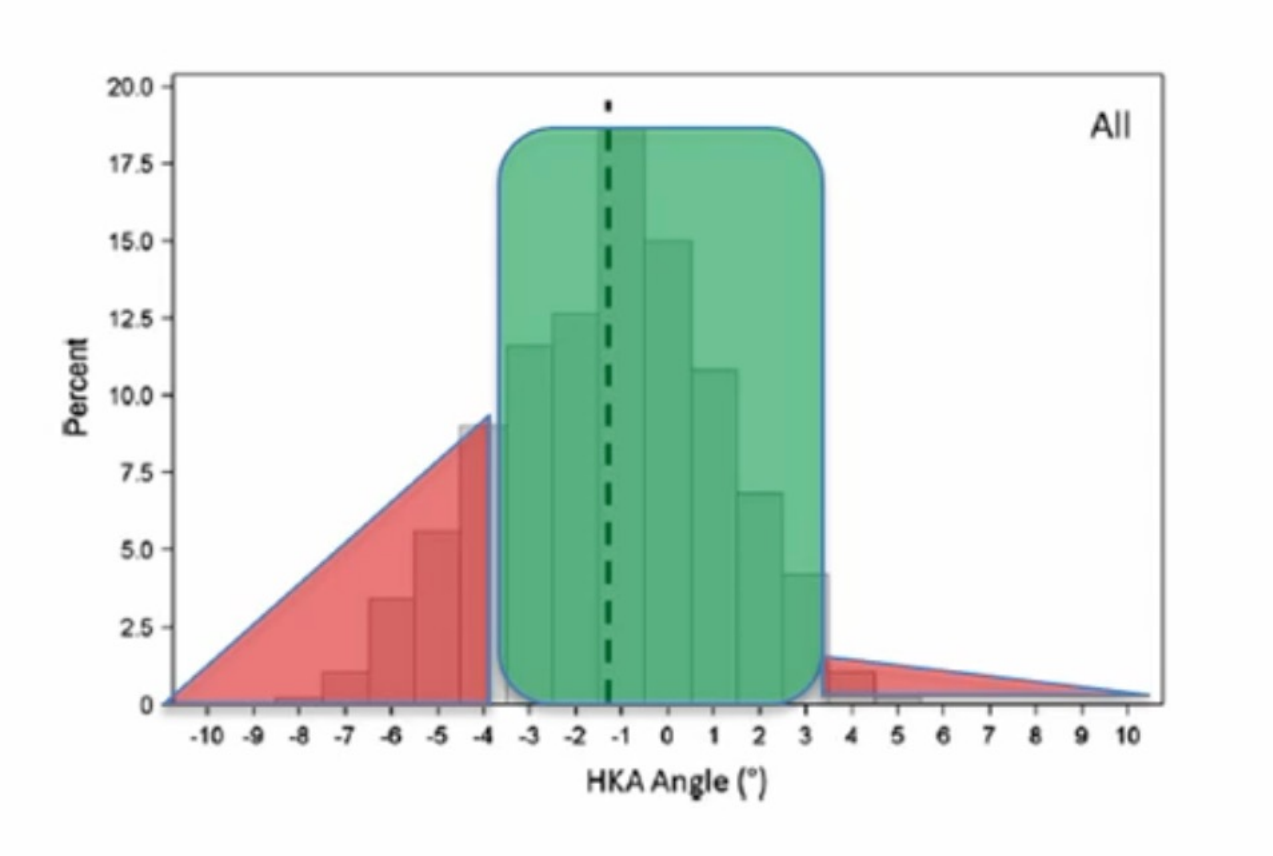
Outliers



Are these beyond the tolerance of the implants?

Kinematic Alignment

Constitutional varus	**YES**
Joint line obliquity	**YES**
Well balanced	**YES**
Well aligned	**MAYBE**
Reproduceable	**MAYBE**

Restricted Kinematic Alignment

Kinematic alignment with guardrails

Limits amount of varus on the tibia

Restricted Kinematic Alignment

Constitutional varus	**YES**
Joint line obliquity	**YES**
Well balanced	**YES**
Well aligned	**YES***
Reproduceable	**MAYBE**

Inverse Kinematic Alignment

Kinematic alignment prioritizing tibial anatomy

Technology dependent for execution

Inverse Kinematic Alignment

Constitutional varus	**YES**
Joint line obliquity	**YES**
Well balanced	**YES**
Well aligned	**YES**
Reproduceable	**YES***

Functional Alignment

- Prioritize concentricity of MFC, trochlear anatomy
- Start at MA/KA, arrive at slightly different targets
- Technology dependent for execution

Functional Alignment

Constitutional varus	**YES**
Joint line obliquity	**YES**
Well balanced	**YES**
Well aligned	**YES**
Reproduceable	**YES***

MA/AA / KA/rKA/iKA/FA

Prioritize the soft tissue envelope

Care to respect the limits of biomaterials

Why?

Easier to balance

Better kinematics

Better outcomes

Institutional Support
Stryker
Arthrex
Medacta
Enovis
Miach Orthopedics

Paid Consultant
Stryker
Medacta

Education

2004	Computer Science
2008	Medical Doctor
2013	Orthopedics
2014	Hip & Knee Replacement
2020	Business Administration

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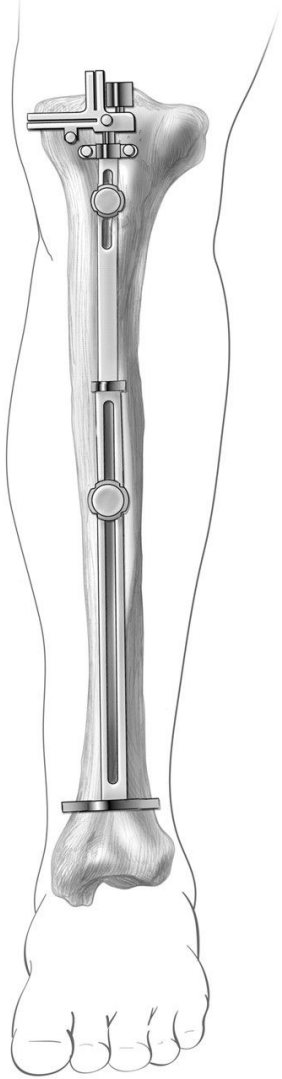
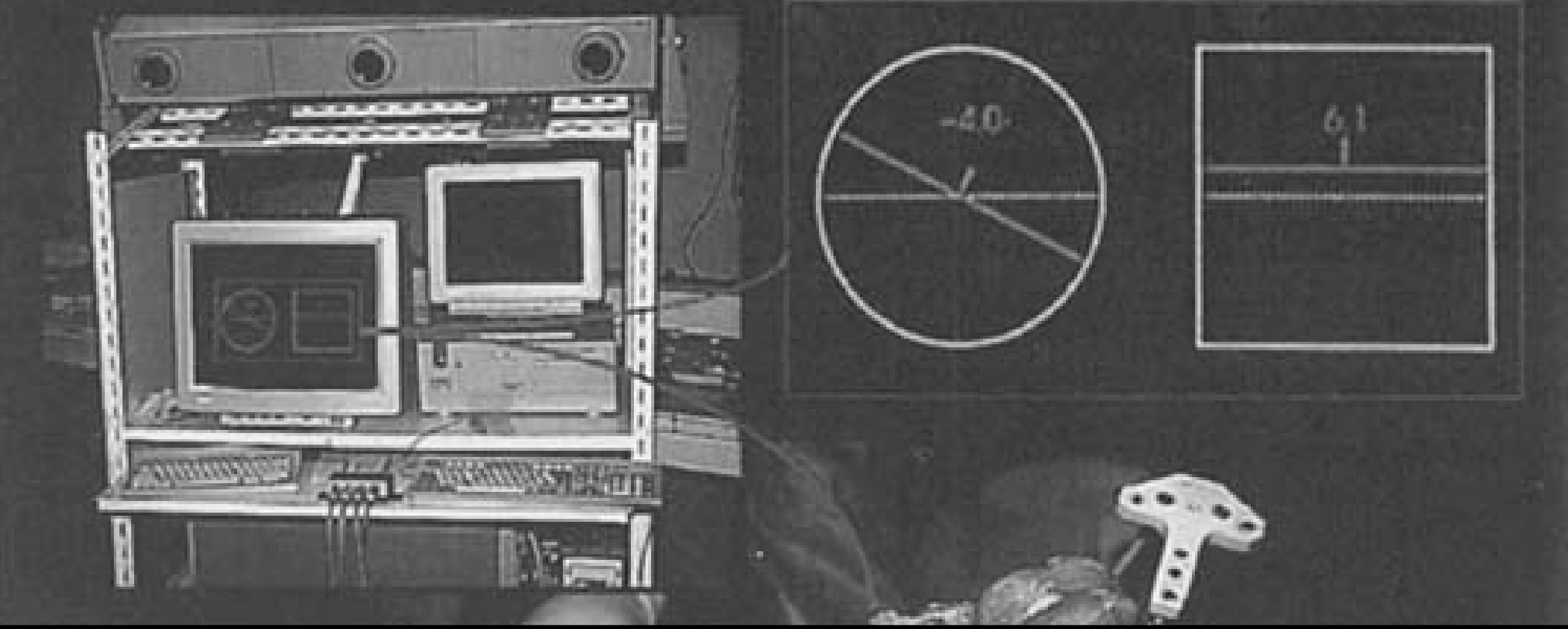
http://www.aaos.org/disclosure

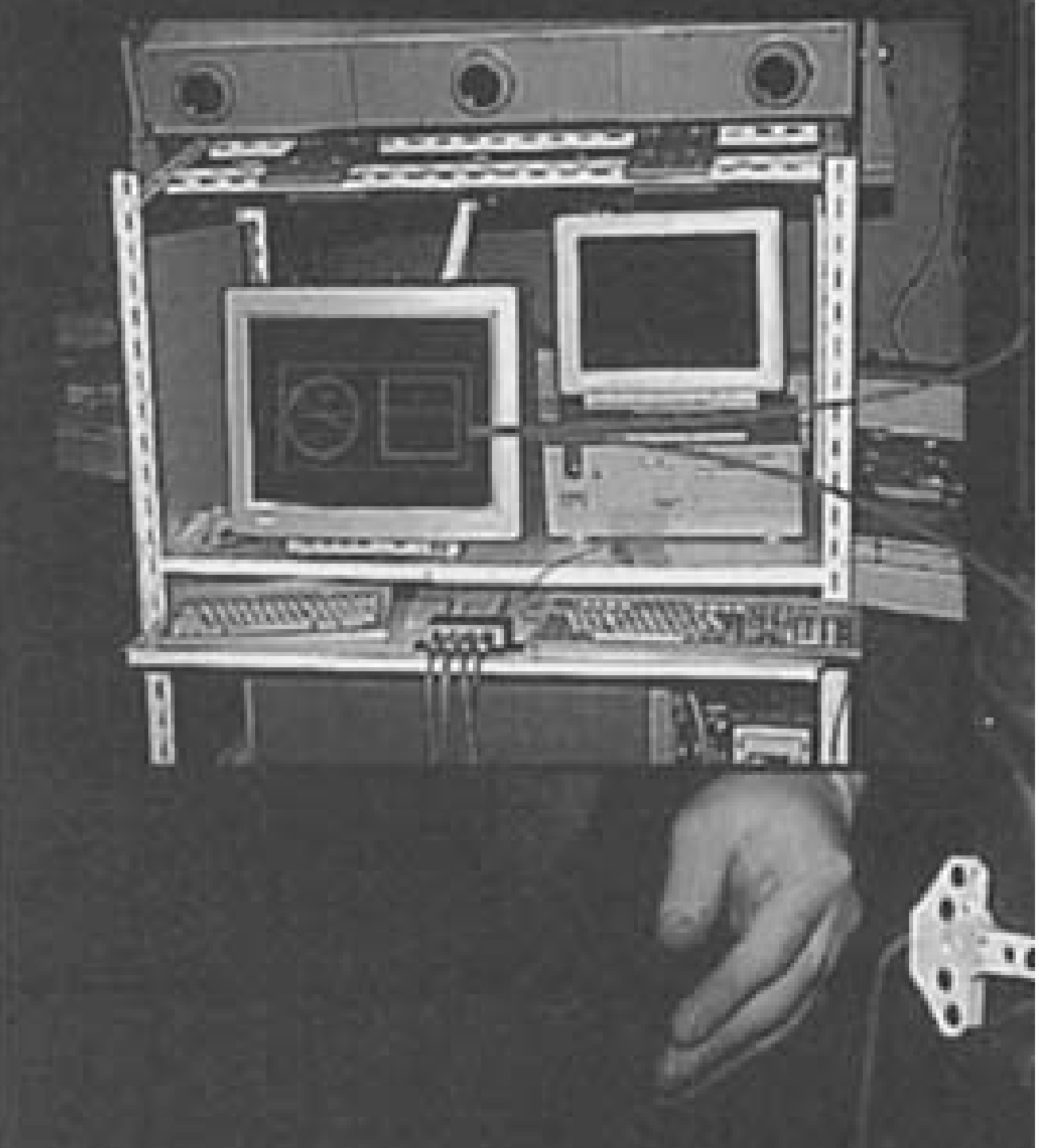
The Alignment Tool





Computer Assisted Knee Replacement.

Delp SL, Stulberg SD, Davies B, Picard F, Leitner F. CORR 1998:49–56.



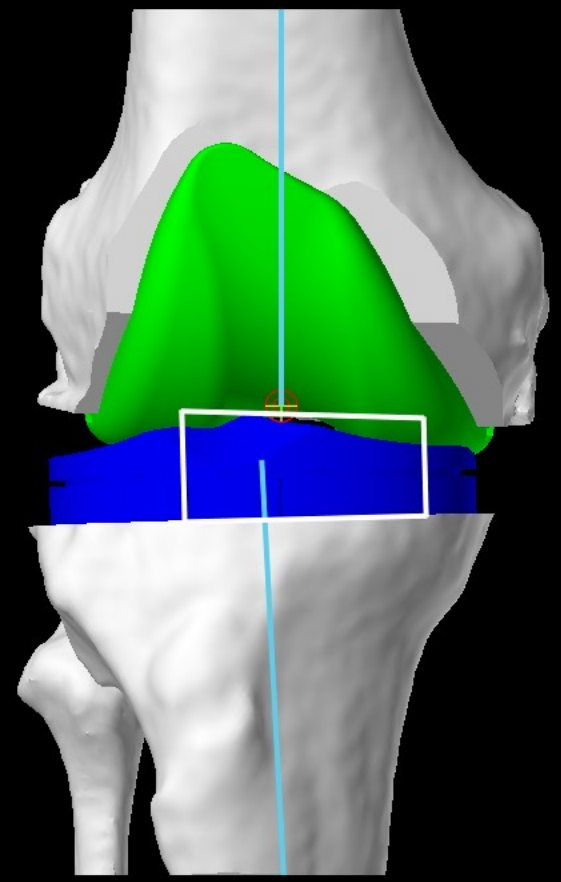

stryker
Position Implant

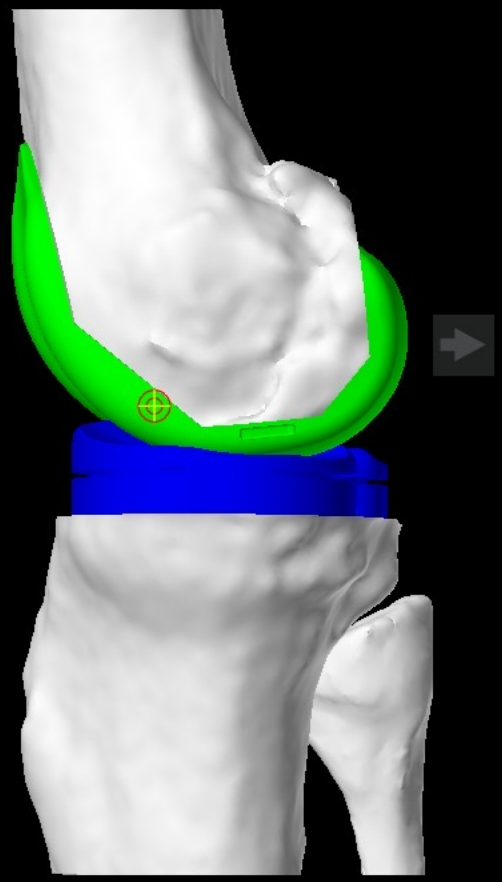
2008/2014

2015

2019

2022





Limb Flexion
2°

Limb Varus
3°

Planned Valgus
1°

	L	M
Extension	21mm	20mm
Flexion	22mm	17mm

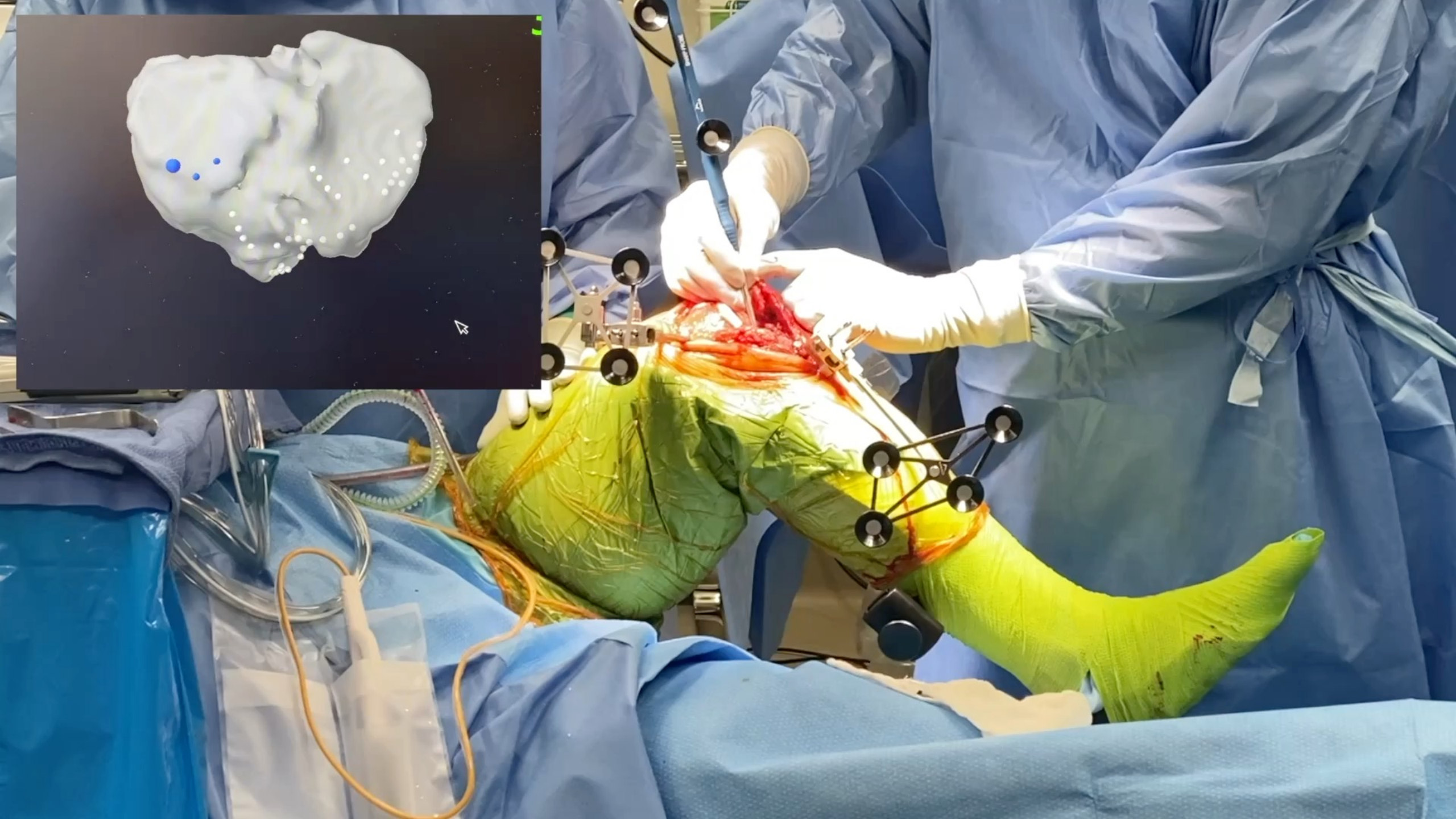
Triathlon® CR Cruciform

Femur	–	7	+
Tibia	–	7	+
Poly	–	9	+

Capture Pose

Femur checkpoint too close to cut
Combined component flexion > 8°
Tibia External rotation: 9°

Ligament Balancing



Personalized Knee Replacement

More anatomic reconstruction
Preservation of soft tissues around knee
Bone preserving

Less pain
More normal feeling knee
Faster recovery

Significant variation in alignment choices and outcomes

MA/AA / KA/rKA/iKA/FA

Orthopedic robots allow us to make precise resections and collect data about resections, alignments & balancing choices from every case.

Choices that lead to better outcomes?

Forté
SPORTS MEDICINE
AND ORTHOPEDICS