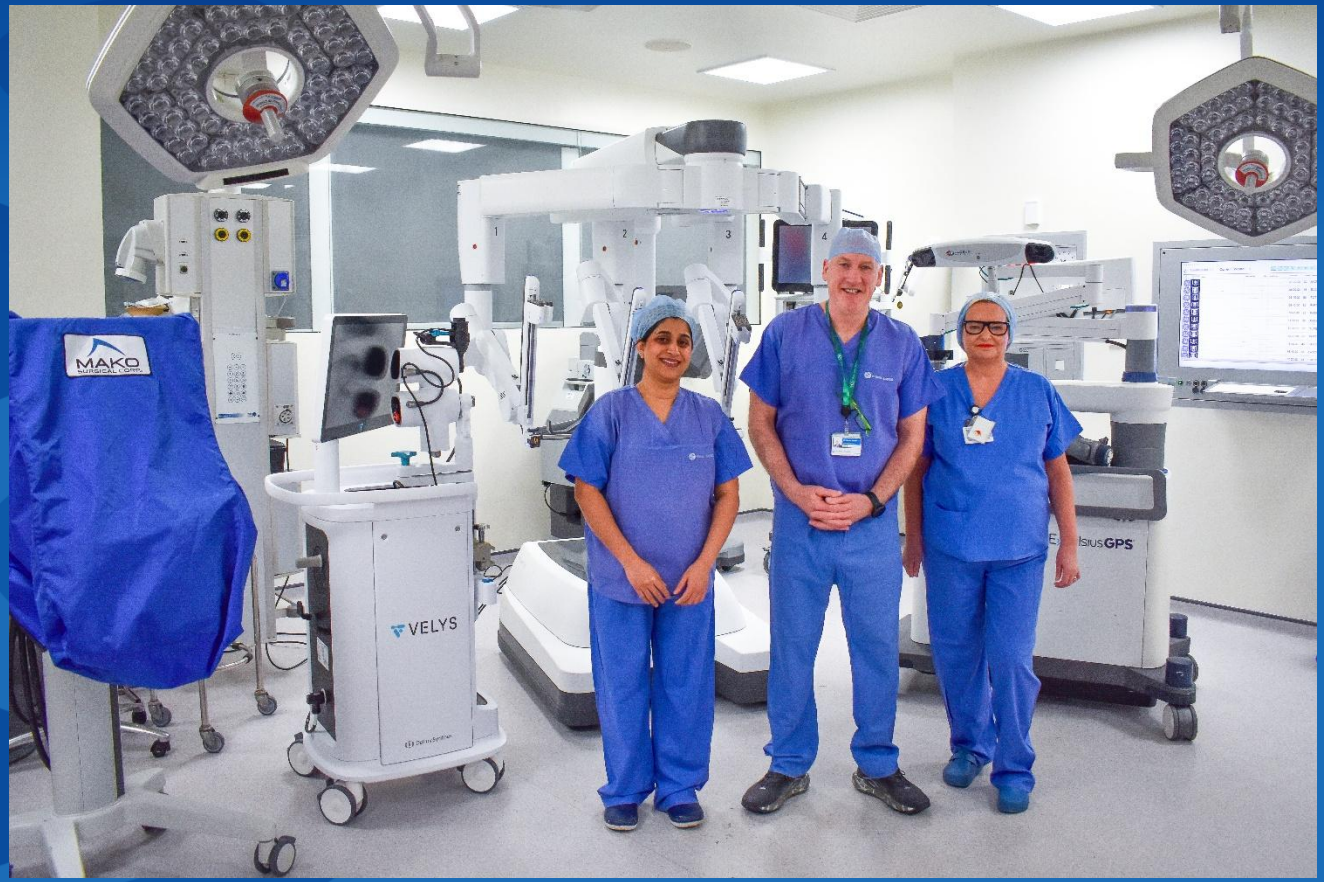
ROBOT WARS

Maurice Neligan
Director of Orthopaedic Surgery
GP Study Day
January 2026

Beacon Hospital
THIS IS MODERN MEDICINE



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Current Robots in Beacon Surgical Department

Da Vinci

- Colo-rectal surgery
- Urology
- Thoracic surgery
- Head & Neck surgery
- Gynaecology

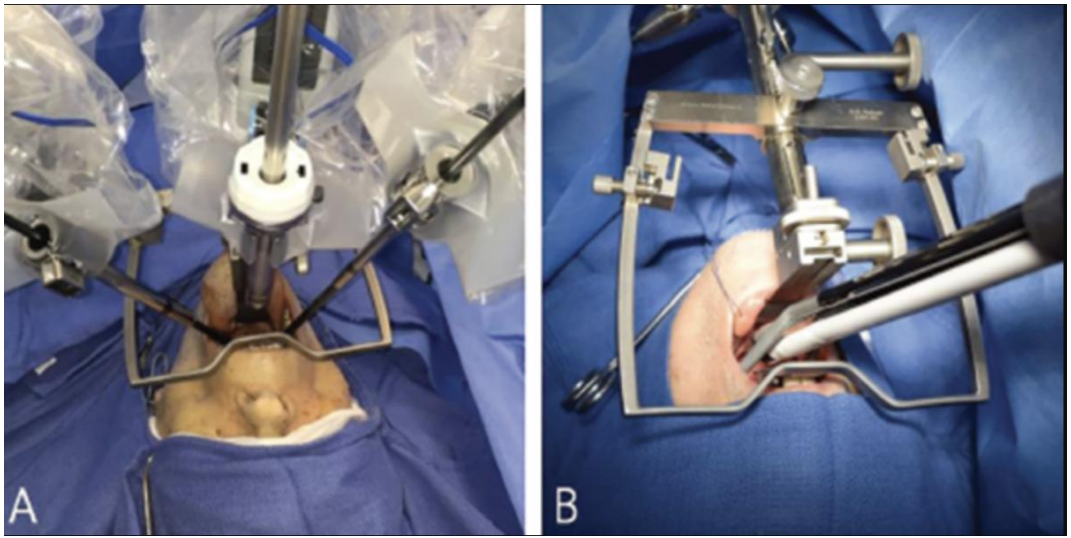
CyberKnife

- Radiotherapy

Globus- Spine

Velys- Knee & Hip

Mako- Knee & Hip



Types of Robots

Tele-operated (Master-Slave systems)

- Da Vinci
- Surgeon operates from remote console

Image-Guided Navigation Systems:

- **Description:** These act like a GPS, integrating imaging (CT, MRI) and sensors to guide the surgeon's tools to precise locations, improving accuracy in hard-to-reach areas.
- **Examples:** Used in **orthopedic surgery** (like knee/hip replacements with Mako SmartRobotics) and **neurosurgery**.

Knee Replacement and Robotics

- Why the need
  - 80% Happy
  - 15% Thought they would be better
  - 5% worse that before TKR
  - Very few of this 20% have identifiable, addressable c
- This essentially unchanged in last 30 years
- Multiple solutions proposed
  - Surgical philosophy
  - Implant design
  - Focal knee replacement
  - Pre-habilitation
  - Patient selection

Knee Replacement and Robotics

Hip OA is essentially solved with THR

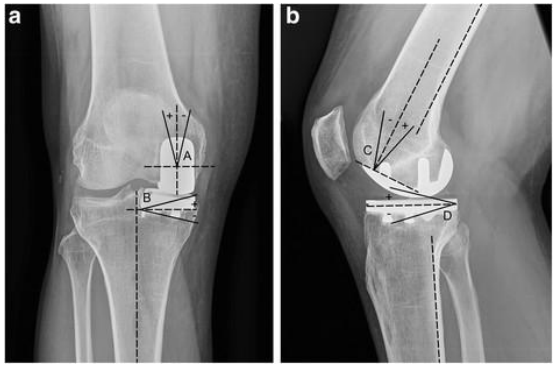
- >95% patient satisfaction
- ~ 70% " Forgotten Joint" at 1 year
- Improvements now in exposures and minimizing rehab period
- In my opinion no pressing indication to develop robot solutions for THR

Appropriate focal knee resurfacing (PKR) results approach those of THR

- Limited but expanding indications for this
- Patient selection is key

TKR vs PKR

- TKR and PKR are different philosophies
- PKR essentially a re-surfacing operation
- TKR removes ligament(s) and is a powerful tool to correcting deformity and allows soft tissue balancing
- PKR preserves ligaments and has a more “natural” feel for the patient
- Both suitable for robotic surgery but different software required



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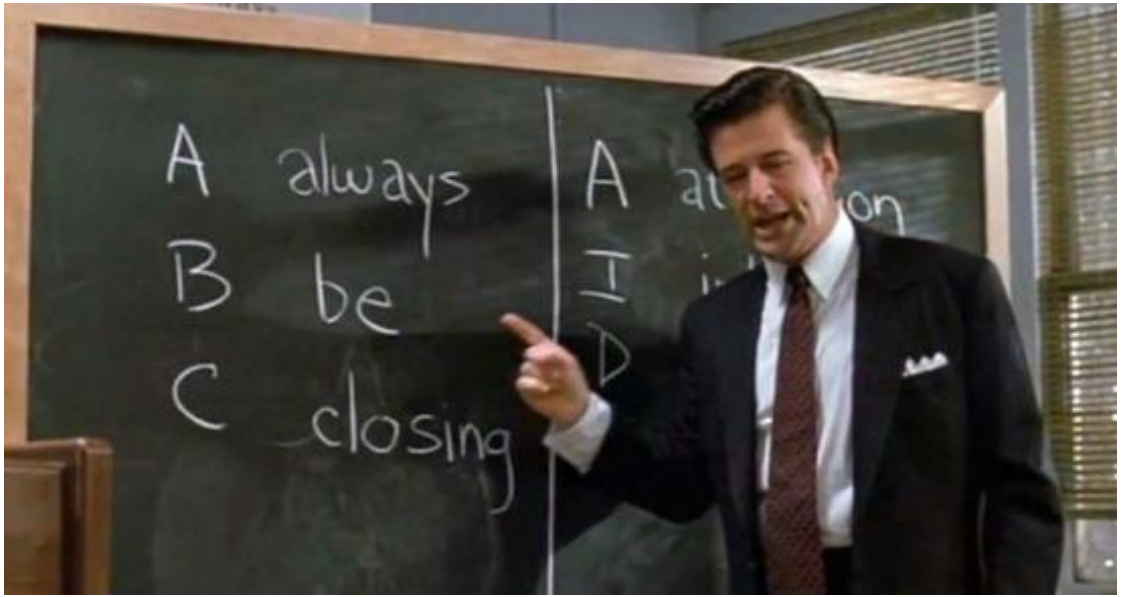
Marketing……..



MAKOplasty is a robotic-assisted surgery for partial or total knee replacement, using the MAKO system for enhanced precision in treating osteoarthritis

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Deciding what, where and why

Comparing actual to anticipated

Deciding how, who and when

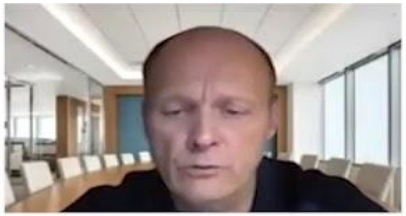
Actually doing it

Indications

- Significant pain with daily activities
- Significant diminution in QOL
- Night pain
- Progressive valgus deformity

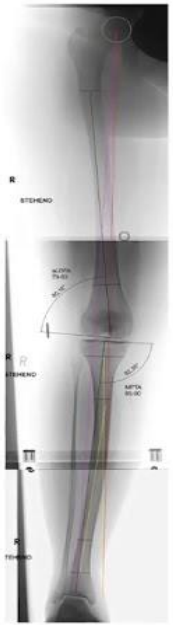
- This is a clinical decision in conjunction with patient (and family)
- Robot not involved yet!

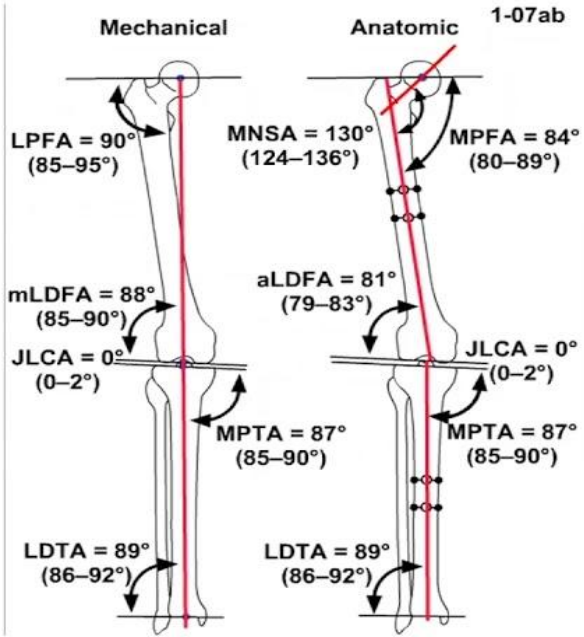
TKR Planning

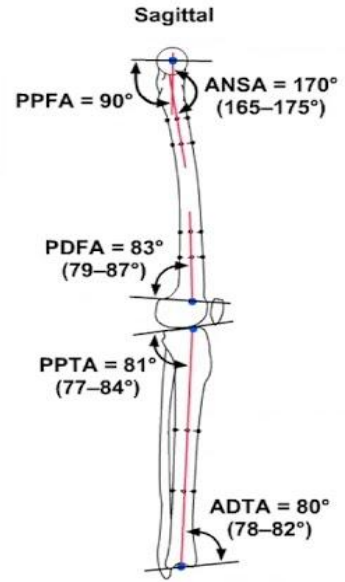


Conceptual Orthopedics
The Learning Never Ends

Long Leg View – Alignment







Alignment Philosophies in TKR

- Mechanical
  - Gold standard until last decade
- Anatomical
- Kinematic
- Restricted Kinematic
- Functional
  - Personalized
  - Inverse Kinematic

Knee Phenotypes

Bone Joint J. 2021 Feb 1;103-B(2):329–337. doi: 10.1302/0301-620X.103B2.BJJ-2020-1050.R1

Coronal Plane Alignment of the Knee (CPAK) classification

a new system for describing knee phenotypes

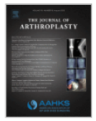
Samuel J MacDessi [1,2,3,✉], William Griffiths-Jones [1,4], Ian A Harris [5,6], Johan Bellemans [1,7,8], Darren B Chen [1,2]

ELSEVIER

The Journal of Arthroplasty

Volume 40, Issue 8, August 2025, Pages 2023-2034

Go to The Journal of Arthroplasty on ScienceDirect



Primary Knee

Three-Compartment Phenotype Concept of Total Knee Arthroplasty Alignment: Mismatch Between Distal Femoral, Posterior Femoral, and Tibial Joint Lines

Silvan Hess MD [a], Sabrina Chelli MD [a], Vincent Leclercq MSc [b], Sébastien Lustig MD, PhD [c], Heiko Graichen MD [d], Michael T. Hirschmann MD [a e f]

KSSTA Knee Surgery Sports Traumatology Arthroscopy

THE OFFICIAL CLINICAL JOURNAL OF ESSKA

KNEE ARTHROPLASTY

A three-dimensional scoring system for assessment of individual bony and laxity phenotype restoration (knee SIPR) in personalised TKA as a base for treatment guidance

Heiko Graichen, Thomas Grau, Rüdiger von Eisenhart-Rothe, Sebastien Lustig, Tilman Calliess, Mark Clatworthy, Michael T. Hirschmann

First published: 10 February 2025 | https://doi.org/10.1002/ksa.12601 | VIEW METRICS

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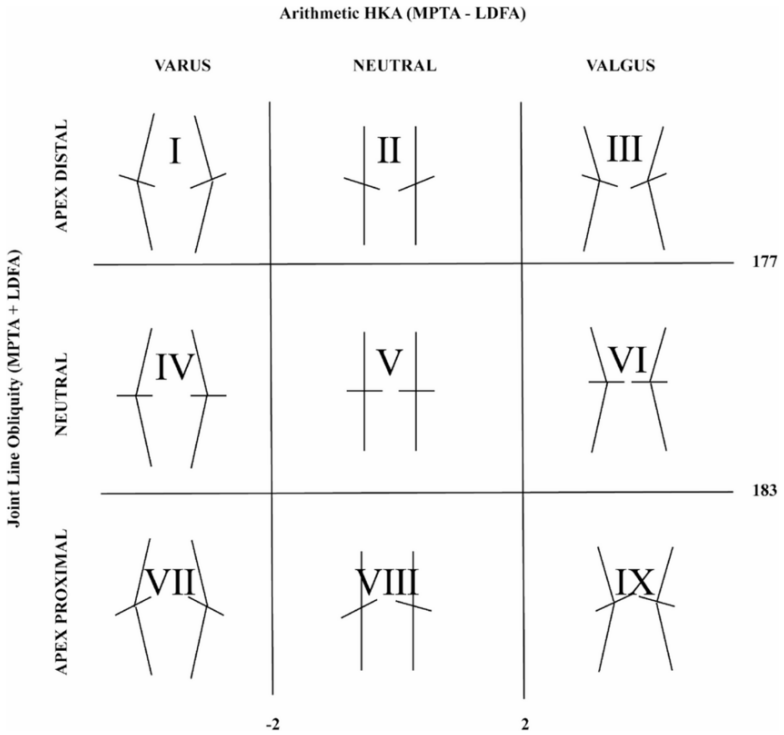
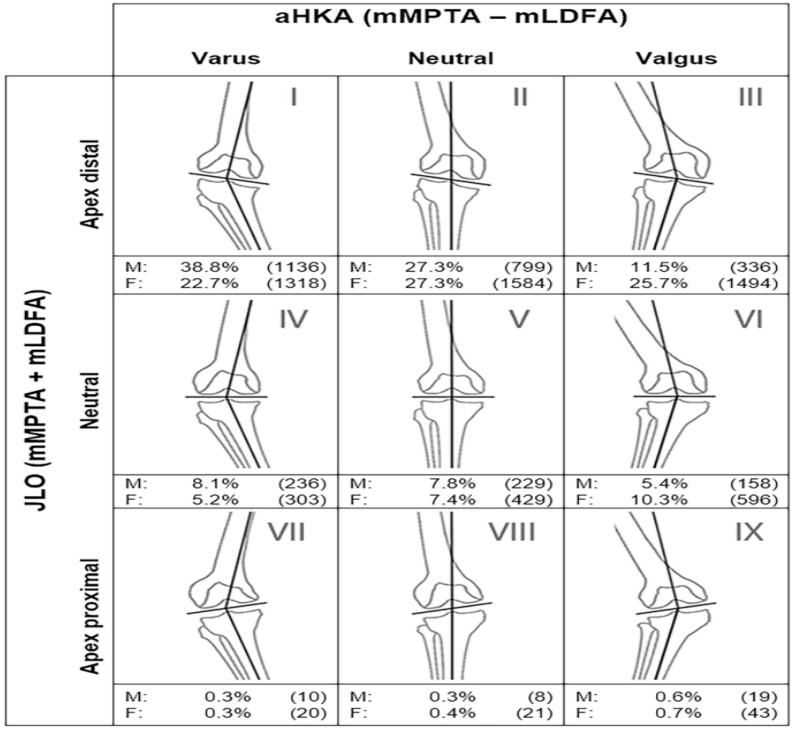
Knee Phenotypes -CPAK





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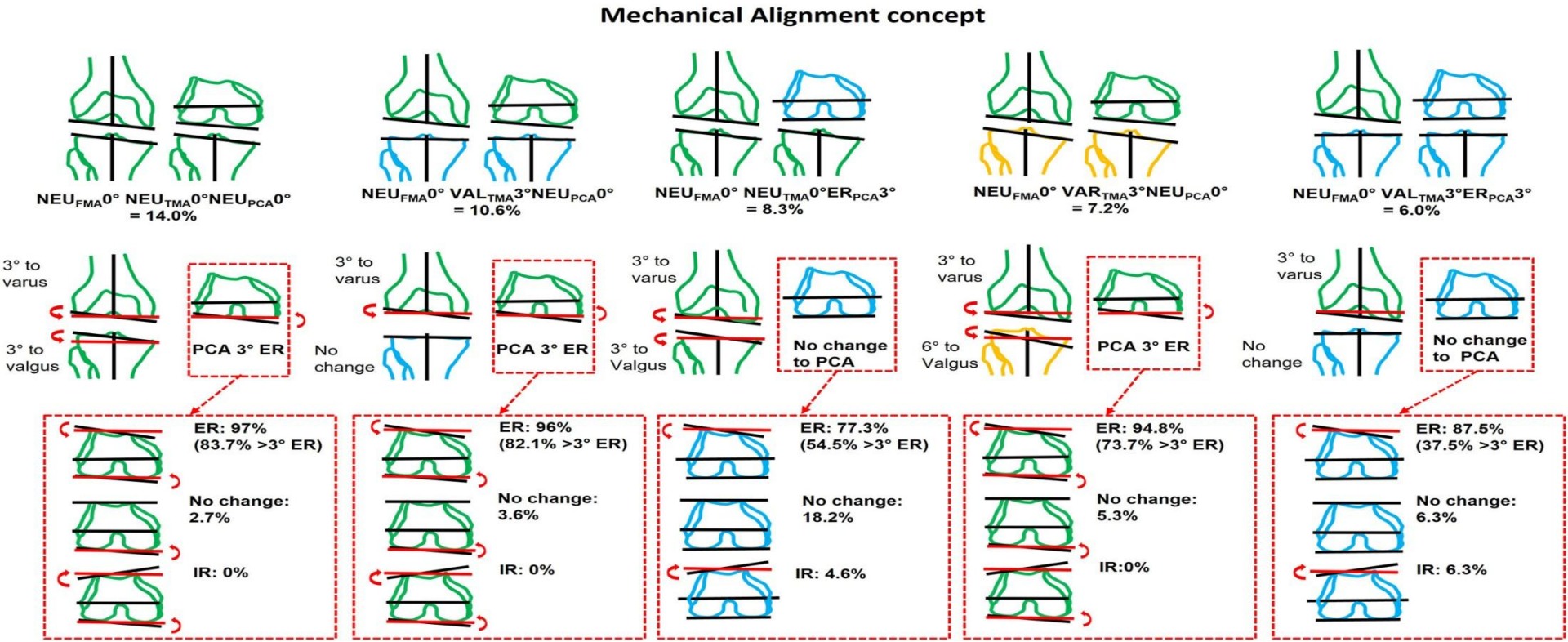
Knee Phenotypes- Hirschmann



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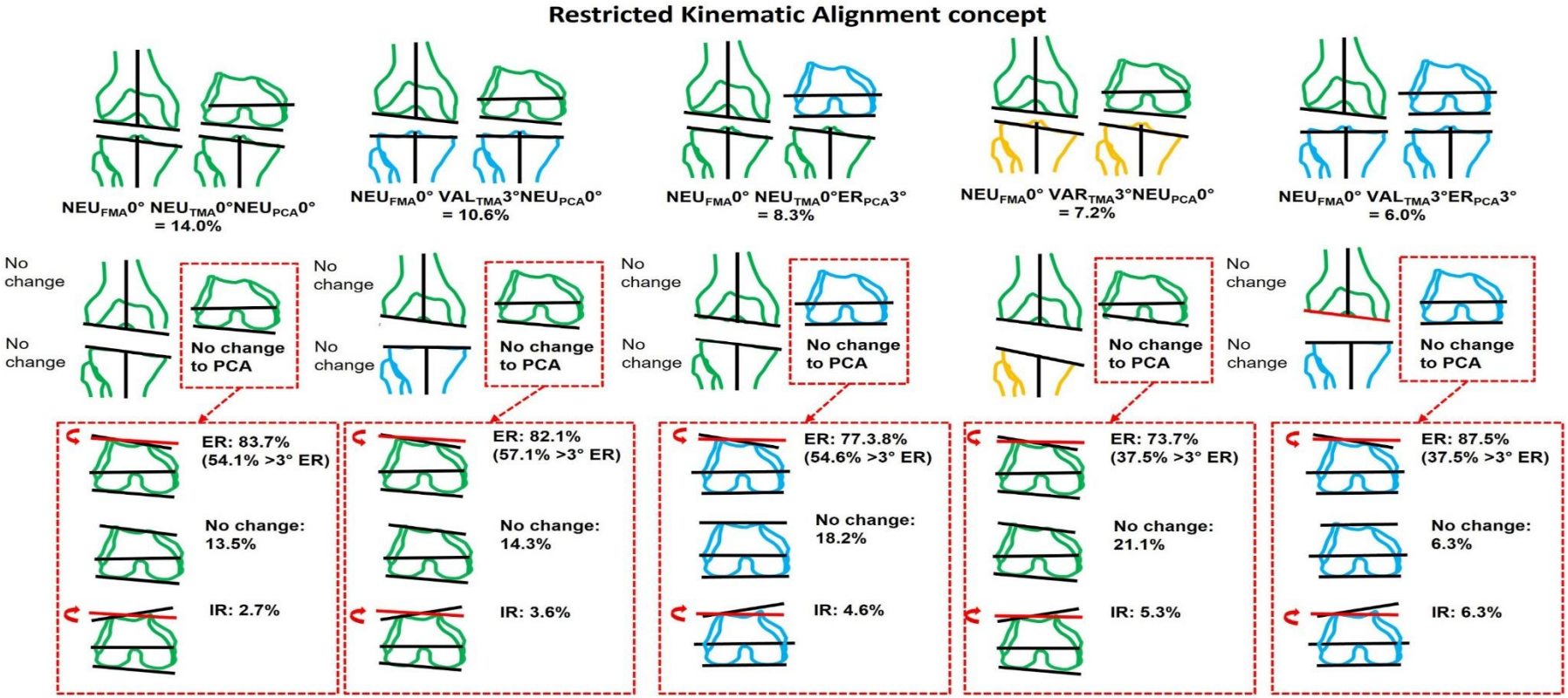
Knee Phenotypes- Hirschmann



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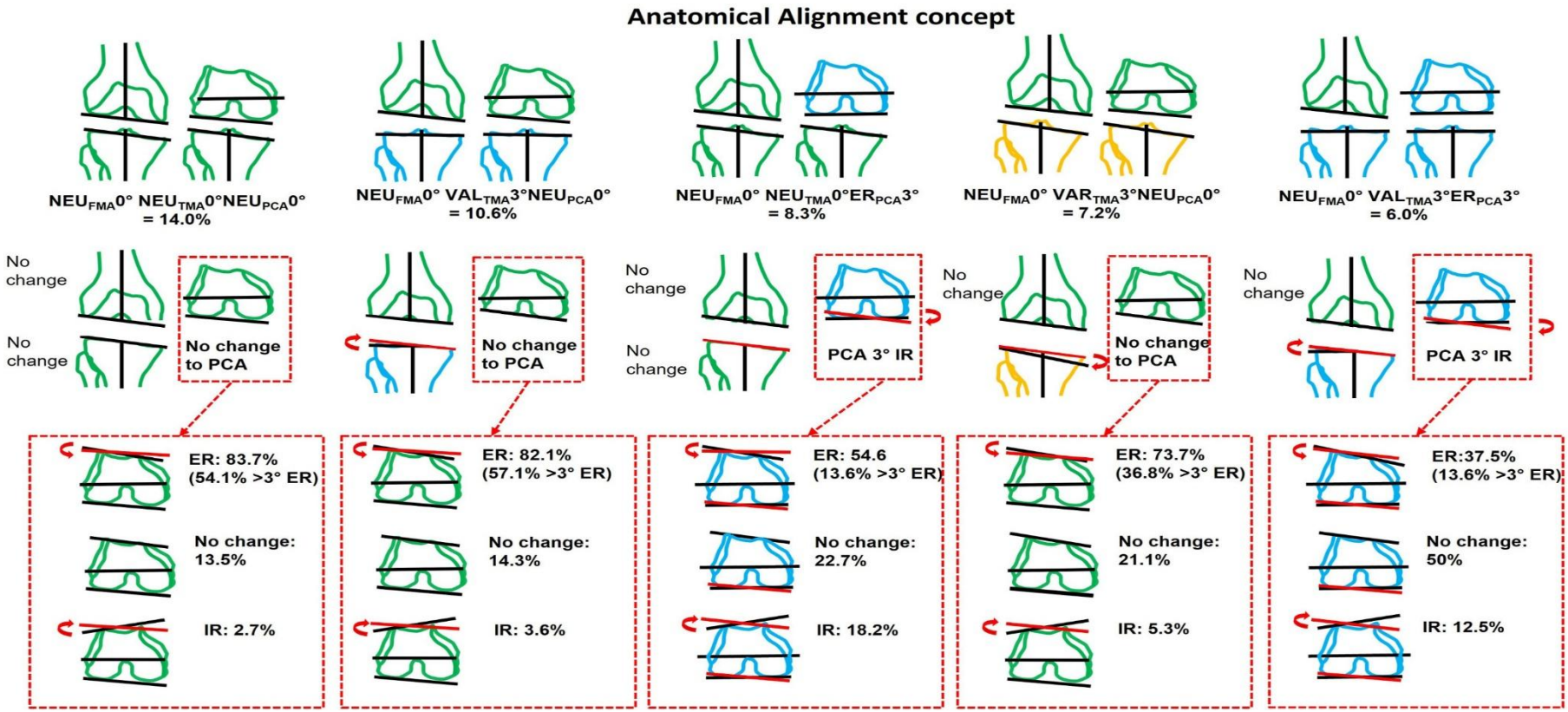
Knee Phenotypes- Hirschmann



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CPAK + Hirschmann Phenotypes + Lustig Ligamentous Laxity

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Pick a Philosophy & Stick to it!

Inverse Kinematic TKR

Tibia-First Approach: The procedure begins by resecting the tibia to match its pre-arthritic, native joint line obliquity.

Gap Balancing: Unlike standard Kinematic Alignment (KA) which typically starts with the femur, iKA uses the initial tibial cut as the reference to then adjust femoral resections.

Soft Tissue Preservation: The goal is to achieve a balanced knee throughout its range of motion without extensive soft tissue releases, as the bone cuts are tailored to the patient's existing ligamentous tension.

Restricted Boundaries: In 2026, "restricted" iKA (riKA) is common, where surgeons keep bone cuts within a "safe zone" (e.g., 84° to 92° for the tibial angle) to avoid extreme outliers that might affect long-term implant survival.

Robotic Procedure-Considerations

Are you trained?

- Education- In Person, On-line
- Hands on training, Cadaver, Saw Bones
- Case Observation

Do you have good support?

- Nursing staff, Assistants, HKA
- Industry

Room set up

Patient positioning and prep

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Robotic Workflow

- **Registration:** The surgeon maps the patient's anatomy using intraoperative landmarks. CT scan may be used (Mako)
- **Anatomic Tibial Resection:** Equal medial and lateral bone is removed (accounting for wear) to restore the native joint line.
- **Tensioning:** A device measures soft tissue gaps in both flexion and extension.
- **Femoral Planning:** The femoral component's position is virtually adjusted to match these measured gaps perfectly.
- **Final Resections:** The robot/surgeon executes the planned femoral cuts, resulting in a naturally balanced joint.

Registration- Velys VRAS (J & J)

Handshake

Saw registry

Array placement

Medial & Lateral Malleoli

Tibia Centre

Whitesides Line

Anterior Femur

Hip Centre

Registration

Tibial registration

- Low point of worn side
- High point of unworn side

Femoral registration

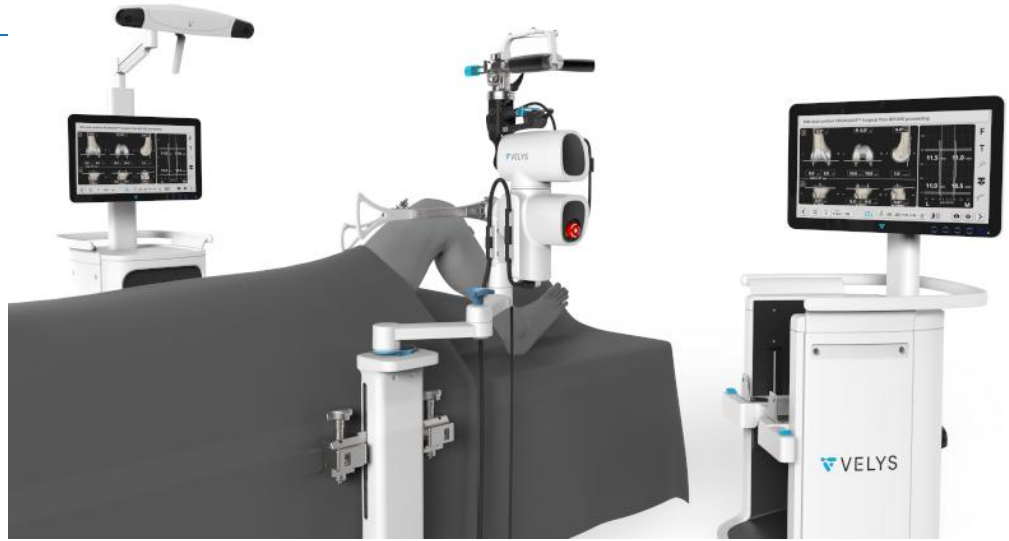
- "Painting" of

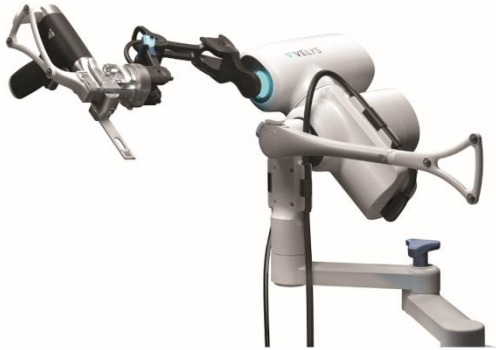
  Distal MFC & LFC

  Posterior MFC & LFC

250 data points of each

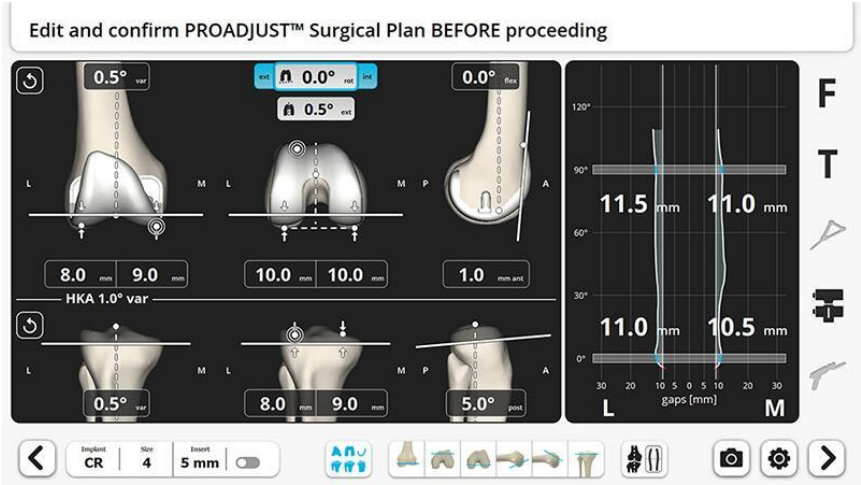
Confirmation of Above





Intra-operative Flow

- Tibial cut first
- Tensioning device to reproduce ligament tension equally through ROM
- Planning Screen
- Confirm final plan
- Femoral Cuts (any order)
- Trial
- Recuts easy (huge benefit)
- Component implantation



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Results

March 6, 2023 / Orthopaedics / Hip & Knee

Robot-Assisted vs. Manual Total Knee Replacement: It's a Tie...for Now

Robot scores better in length of stay and home discharge; manual scores better in flexion and operative time

Meta-Analysis > Eur J Orthop Surg Traumatol. 2024 Apr;34(3):1333-1343.

doi: 10.1007/s00590-023-03798-2. Epub 2023 Dec 22.

Robotic-assisted versus conventional total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials

Reda Alrajeb [1], Mohammed Zarti [1], Zakaria Shuia [1], Osama Alzobi [2], Ghalib Ahmed [3], Aissam Elmhiregh [1]

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Pros of Robotic TKR

- **Enhanced precision:** Robotic systems allow for sub-millimetre and sub-degree accuracy in bone cuts and implant alignment. This precision is particularly beneficial for complex cases with substantial deformities.
- **Personalized Planning:** Surgeons use CT scans or intra-operative registration to create a 3D virtual model of your unique anatomy before the first incision, tailoring the procedure to your specific bone structure.
- **? Faster Early Recovery:** Patients often report less pain and a quicker return to early milestones, like independent walking or stair climbing, in the first 1–2 weeks post-surgery ?
- **? Minimally Invasive:** The precision of the robotic arm reduces trauma to surrounding soft tissue and ligaments, often resulting in smaller incisions and less blood loss ?
- **? Potential Longevity:** Improved alignment is expected to reduce long-term wear and tear on the implant, potentially extending its lifespan to 20–25 years?

Cons of Robotic TKR

- **?Higher Costs:** The technology typically makes the procedure 20–30% more expensive than traditional surgery. Insurance coverage for the "robotic" portion may vary. Closed platforms currently ?
- **?Longer Operative Time:** Setting up the robotic system and performing the intraoperative mapping can add time to the surgery ?
- **Learning Curve:** Successful outcomes depend heavily on the surgeon's specialized training with the specific robotic platform.
- **?Limited Availability:** Advanced robotic systems are primarily found in larger (and private) hospitals ?
- **?Additional Incisions:** Small extra cuts may be needed to insert pins that hold sensors for the robot to track the bone's position, Possible ⇧ # risk ?
- **Lack of Long-Term Comparative Data:** While short-term results are promising, there is currently limited evidence proving that robotic surgery results in significant improvement in long term outcome (15-20 years)

Future Directions

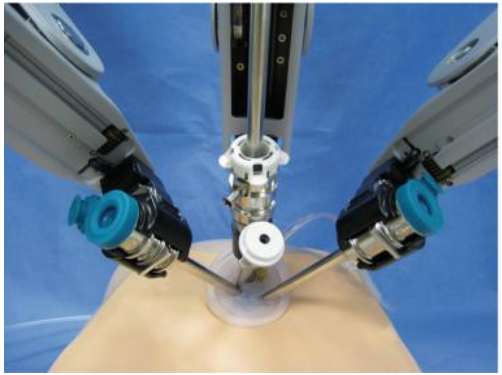
- **Single-Port Innovations:** Systems like the **da Vinci SP** and **SHURUI SP** (which received CE certification in August 2025) allow entire procedures through a single incision, further reducing trauma.
- **AI Integration:** New AI-assisted platforms provide real-time decision support, predictive analytics, and automated suturing.
- **Early Autonomy:** While most surgery remains human-controlled, 2025 saw breakthroughs in **autonomous surgery**, with systems successfully performing tasks like gallbladder surgery on animal models without human intervention.
- **Expanded Competition:** The market has shifted from a monopoly to a competitive landscape with new systems like **Versius**, **Hugo**, and **MUSA** driving down costs and increasing accessibility.

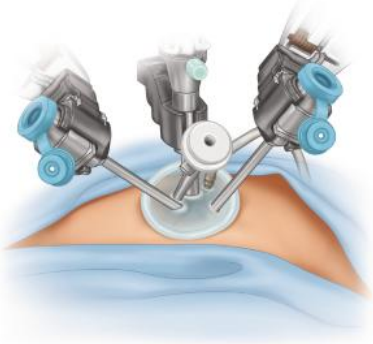
Future Directions

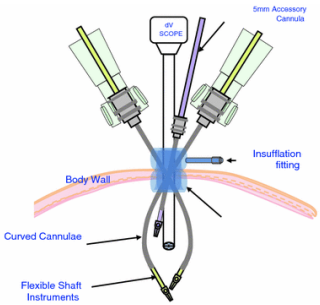
Medscape Medical News > Features

How a Robot Performed Surgery Without Human Assistance

Christina Szalinski
August 28, 2025







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AI in Robotic TKR

Knee Surg Relat Res. 2025 Oct 14;37:44. doi: 10.1186/s43019-025-00295-0

Artificial intelligence in total knee arthroplasty: clinical applications and implications

Kyeong Baek Kim [1,2], Gi Beom Kim [4], Jun-Ho Kim [5], Sang-Min Lee [1,2,3,✉]

AI has the potential to significantly reshape TKA by enabling more precise, data-driven, and patient-centred care. However, its promise is contingent on overcoming critical limitations. Broader implementation requires robust multicentre validation to ensure model reliability, the development of explainable algorithms to build clinical trust, and a commitment to responsible innovation.

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Thank you

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