That's not a crowded OR

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# A Robot, A Fluoroscopy Unit, and a Navigation Station Walk into an OR…

Now that's a crowded OR

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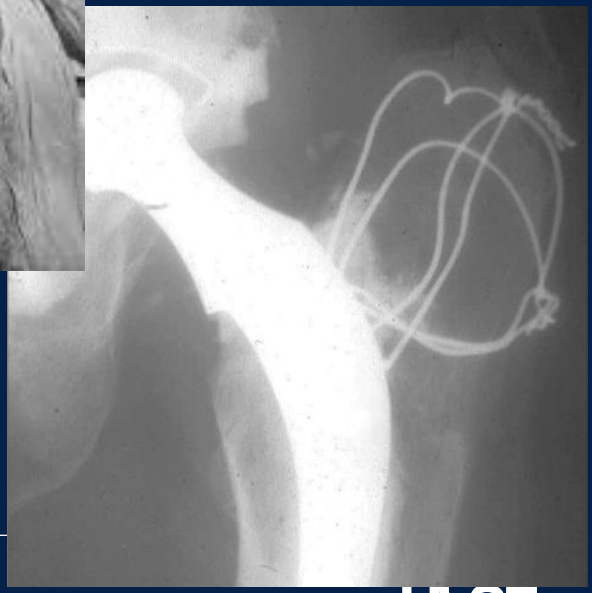
# Disclosures

CORIN- Product development team, Omnibotics 3.0

# THA as the "Operation of the Century"

THE LANCET
Volume 370, Issue 9597, 27 October–2 November 2007, Pages 1508-1519

Review

The operation of the century: total hip replacement



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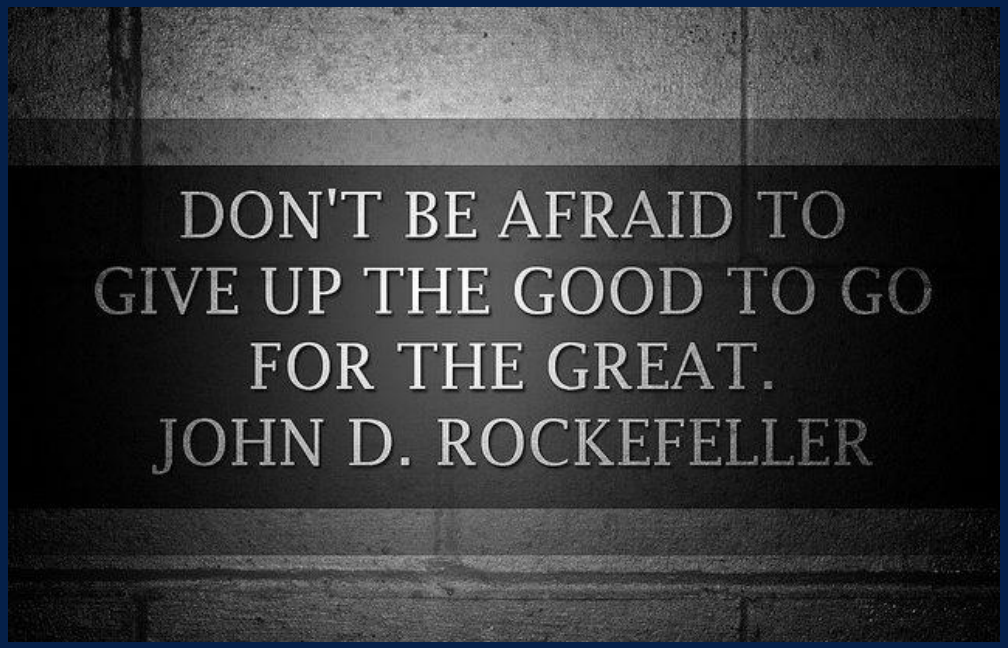
# Can We Improve This Procedure?

- Perioperative Pathways
- Patient Selection/ Optimization
- Surgical Approach
- Instrumentation
- Implants
- Technologic Adjuncts



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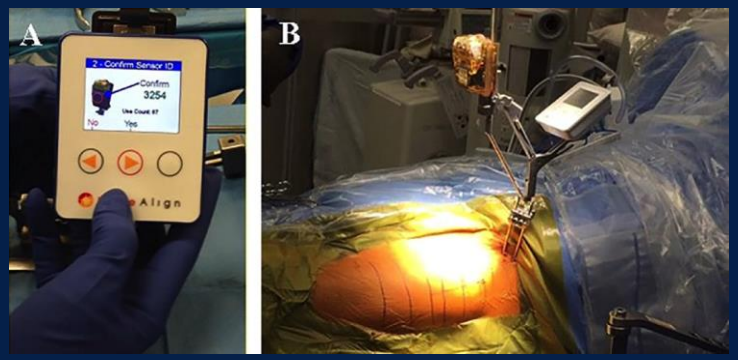
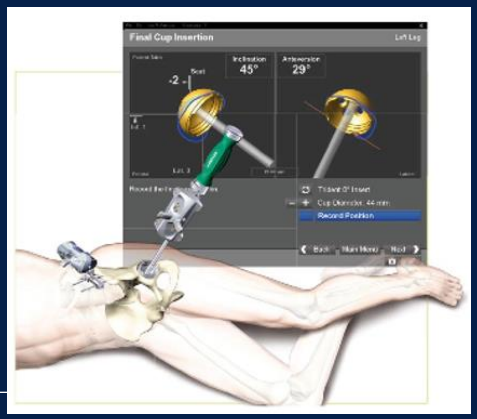
# Technologic Adjuncts




- Fluoroscopy

- Navigation

- Robot

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# Evolution of Hip Surgeon?


Homo Sapiens- Templates & Bony Landmarks



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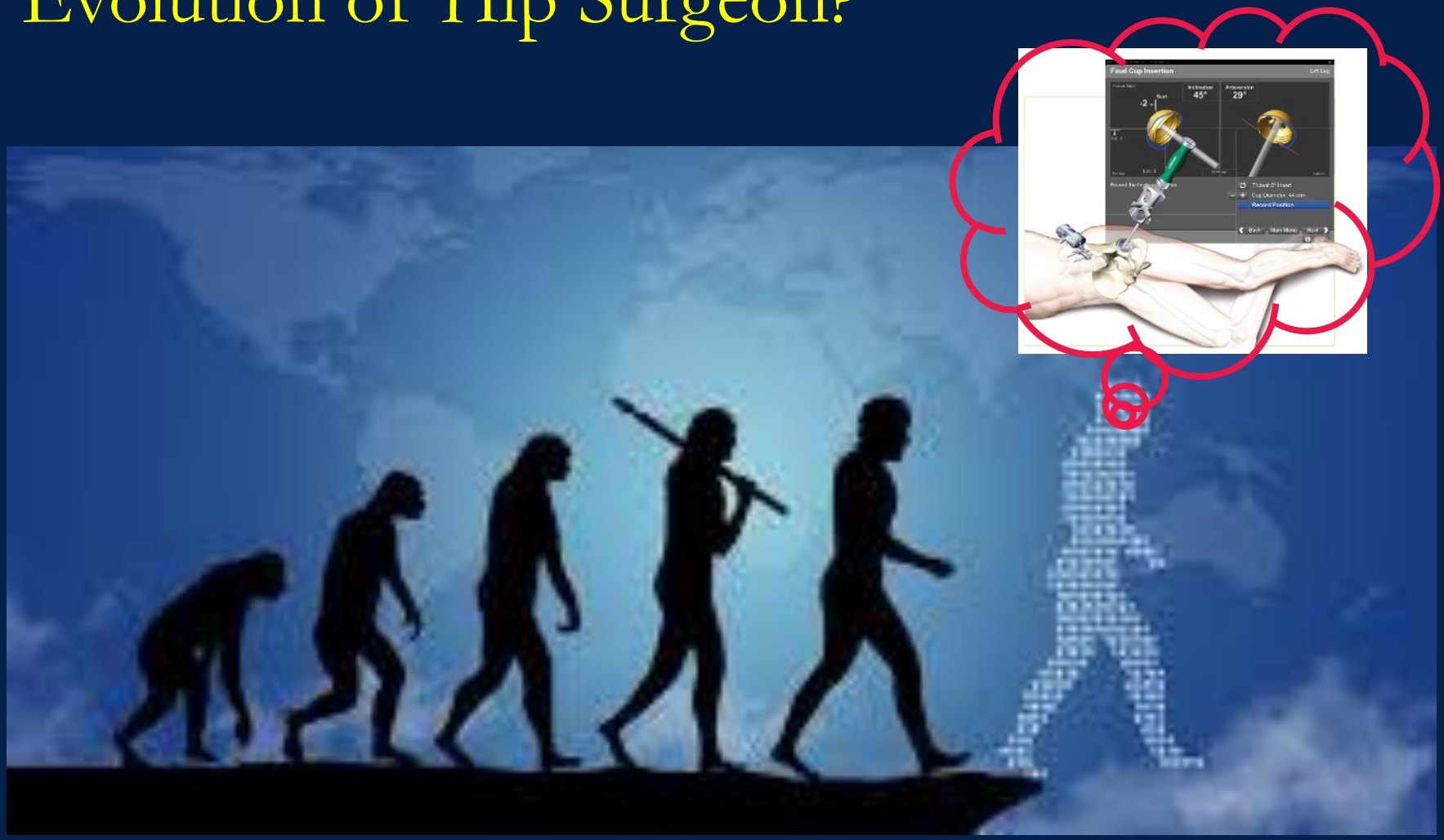
# Evolution of Hip Surgeon?

Homo Fluoroscopis- Intraoperative X-ray

# Evolution of Hip Surgeon?




Homo Navigatus- Intraoperative Navigation



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# Evolution of Hip Surgeon?

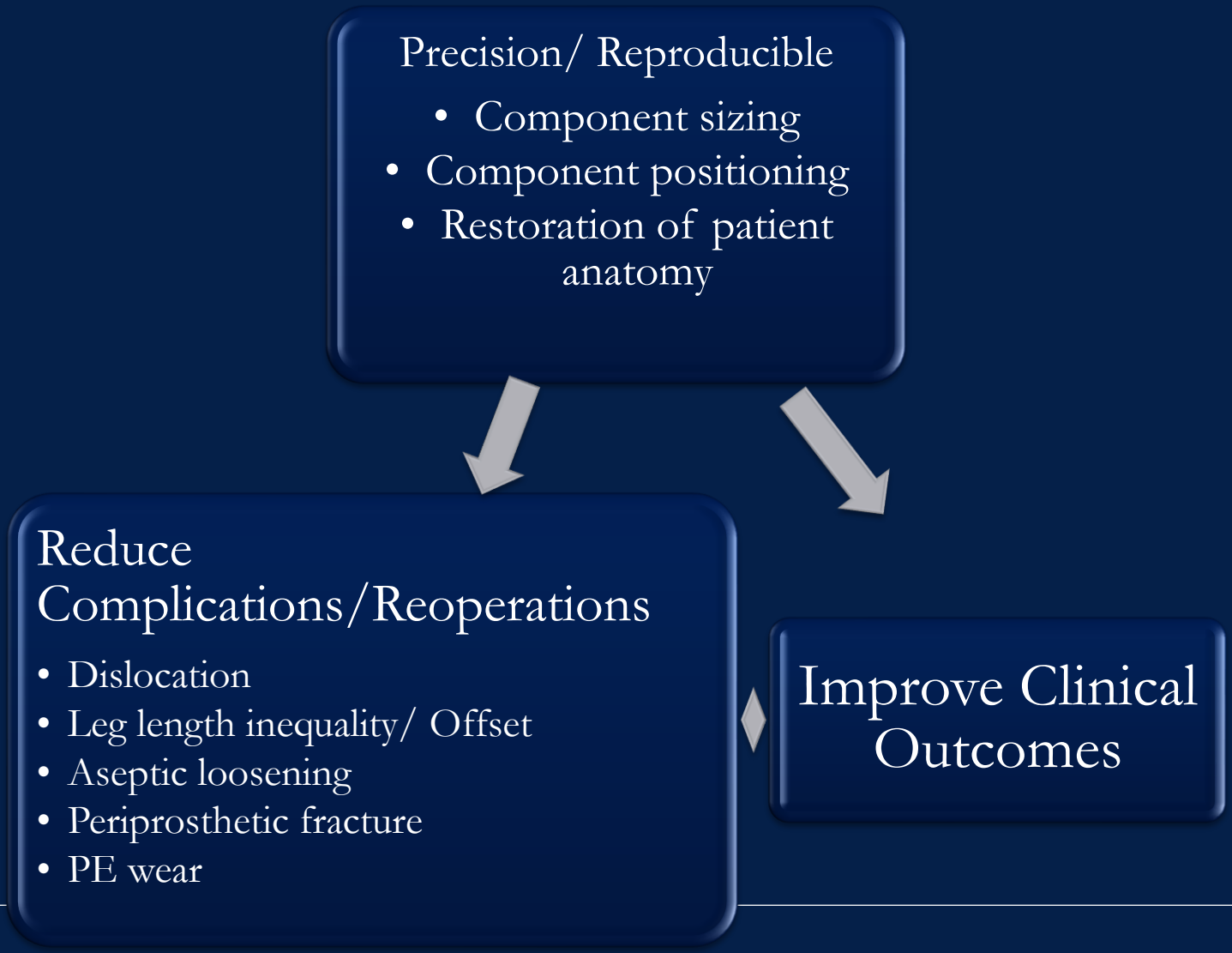
Homo Robotis- Intraoperative Robotics

# Why Technology?

Precision/ Reproducible

- Component sizing
- Component positioning
- Restoration of patient anatomy

# Why Technology?



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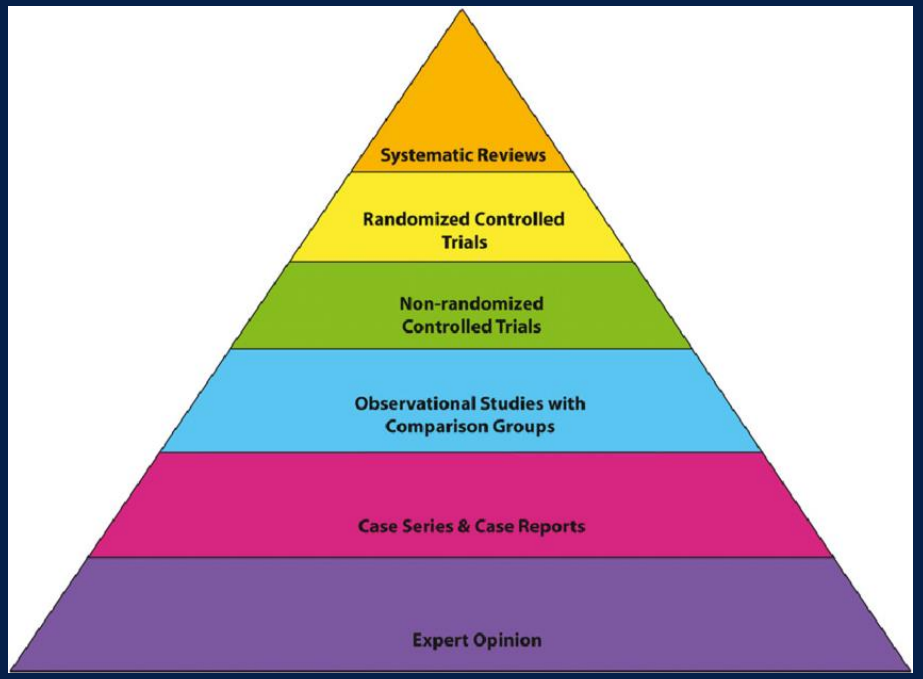
# Literature

- Comparative Studies
  - Technology vs Conventional
  - Technology vs Technology
- Outcomes
  - Radiographic
  - Clinical
- *** Disclaimer ****
  - Multitude of companies
  - Conflict of interest




Pyramid of Evidence



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Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Systematic Review and Meta Analysis

# The Impact of Author Financial Conflicts on Robotic-Assisted Joint Arthroplasty Research

Michael J. DeFrance, DO [a], Michael F. Yayac, MD [b], P. Maxwell Courtney, MD, FRCS [b,*], Matthew W. Squire, MD [c]

[a] Rowan University School of Osteopathic Medicine, Stratford, NJ
[b] Rothman Orthopaedic Institute at Thomas Jefferson University, Philadelphia, PA
[c] University of Wisconsin School of Medicine and Public Health, Madison, WI

- Of 54 studies, 49 (91%) had an author financial COI

- Studies favoring robotics- higher number of conflicted authors and higher mean industry payment/ author



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# Fluoroscopy vs Manual

- Improved acetabular component position
  - DAA- 80% vs 63% in “safe zone” Jennings Orthopedics 2015
  - DAA vs PL- 96% vs 78% Martin Arthroplasty Today 2020
- Achieving equality in LLD/ offset reliable from DAA approach
  - <5mm in 95% of cases Caus World J Orthop 2021, Martin Arthroplasty Today 2020
- Pelvic tilt can affect perceived component position
  - Match size/shape of obturator foramen w/ standing preop AP James J Arthroplasty 2018
- Learning curve for interpretation
  - Accuracy component positioning yearly (79%->91%->96%) Slotkin J Arthroplasty 2015

# Navigation vs Manual

- Quality of Studies- SR/MA (4), RCT (2), Registry/Database (3)

- Radiographic
  - Improved acetabular component position, esp. anteversion Shigemura Orthop Traumatol Surg Res 2021, Liu Int J Surg 2015, Tanino J Arthroplasty 2020
  - More accurate LLD/ Offset Migliorini J Orthop Traumatol 2022, Jia Medicine 2019
  - CT based more accurate than image free navigation, due to variability in pelvic tilt Hasegawa Comput Assist Surg 2021, Tetsunuga Hip Int 2021

- Clinical
  - No diff in Harris Hip Score Migliorini J Orthop Traumatol 2022
  - No diff in dislocation rate Migliorini J Orthop Traumatol 2022
  - Surgical time longer (-10min) Tanino J Arthroplasty 2020

# Navigation- Registry/ Database Studies

- Australian Orthopaedic Association NJR Agarwal JBJS 2021
  - N=6,912 CAS-THA, use in 2009 (1.9%) vs. 2019 (4.4%)
  - No diff in all cause revision for entire group
  - Lower rate of dislocation @10yrs- 0.4% vs 0.8%
  - Sub-analysis of 5 most common THA constructs lower all cause revision rate 2.4% vs 4.2%
- Medicare Database Montgomery J Arthroplasty 2019
  - 2005-2012, N=69K THAs, 5,412 CAS-THA, 60K M-THA
  - CAS not assoc w/ lower rate of dislocation @30d, 90d, or 2yr
  - CAS assoc w/ higher rate of ppx fx , and rev THA @30d
- Nationwide Readmission Database Gausden Int Orthop 2020
  - 2012-2014; N=309K THA, 8,431 CAS-THA, multivariate analysis
  - 12% reduced odds of 90d complications; No diff in revision surgery

# Robotics vs Manual

- Quality of Studies- SR/MA (5), RCT (0), Registry/Database (3)

- Radiographic
  - Consistent improvement in acetabular component positioning and restoration of leg length Clement Bone Joint Res 2021, Domb JAAOS 2020

- Clinical
  - Mixed data on improvements in PROMS
    - HHS and FJS-12 higher, no diff in VAS @ 2yr f/u Perets Orthopedics 2021
    - Higher mean HHS (92 vs 86), pre-postop Delta HHS (43 vs 37), no diff in SF-12 or WOMAC Bukowski Surg Technol Int 2016
    - Forgotten Joint Score higher, though EQ-5D not Clement Bone Joint Res 2021
  - Operative time longer in RA-THA (9min) Bukowski Surg Technol Int 2016

# Robotics- Systematic Review/ Meta Analysis

- Positive (+) Ng Bone Joint J 2021, Kumar Postgrad Med J 2021
  - Improved acetabular component position
  - Improved HHS in short and midterm f/u
  - Increased operative time
  - No diff in complication rate, and survival rates
- Neutral (+/-) Sweet JBJS Rev 2021, Karunaratne Int Orthop 2019, Samuel J Robot Surg 2022
  - Majority of studies found no diff in PROMs, satisfaction
    - 2 low quality studies found sig better PROMs in RA-THA
    - Most studies presented some risk of bias, and strength of evidence rated as low to very low quality
  - No diff in complication/ revision rates
    - 1 study found higher dislocations and revisions in RA-THA

# Robotics- Database Studies

- Nationwide Inpatient Sample- RA-THA, CA-THA and M-THA Emara Bone Joint J 2021
  - No diff in mean LOS
  - Implant related mechanical complications lower in RA and CA-THA vs M-THA (2-3x), primarily dislocation

- Pearldiver Database Remily Arthroplasty Today 2021
  - RA-THA shorter LOS (3.4 vs 3.7d)
  - Readmission rates higher (7.8% vs 6.6%)
  - No diff in surgical outcomes @ all time points

# Technology vs Technology

- Robot vs Fluoro
  - No diff in XR parameters, except inclination (3.8’ vs 4.6’) Stewart J Arthroplasty 2022
- Robot vs Navigation
  - Surgical time (135 vs 146min), # days to independent walking (7 vs 11), postop pain, and HHS (85 vs 81) favored RA-THA. No diff in XR parameters. Shibanuma BMC MSK Disord 2021
- Robot vs Navigation vs Manual
  - Stat sig diff in PROMS but none met MCID
  - LOS longest for M-THA vs Nav-THA vs RA-THA (2.2 vs 1.5 vs 1.9d)
  - OR time longest for RA vs Nav-THA vs M-THA (120 vs 90 vs 95 min) Singh J Arthroplasty 2021



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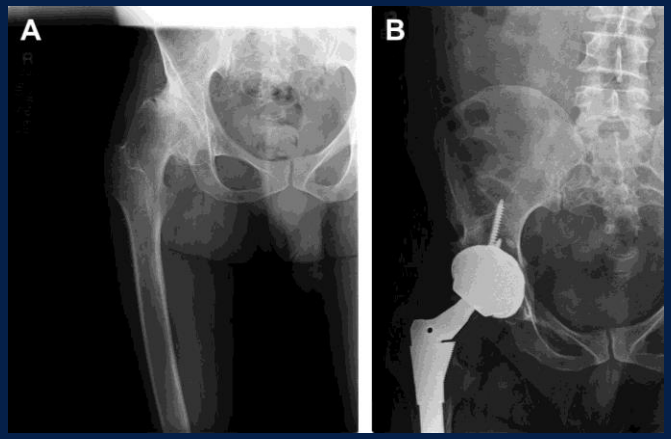
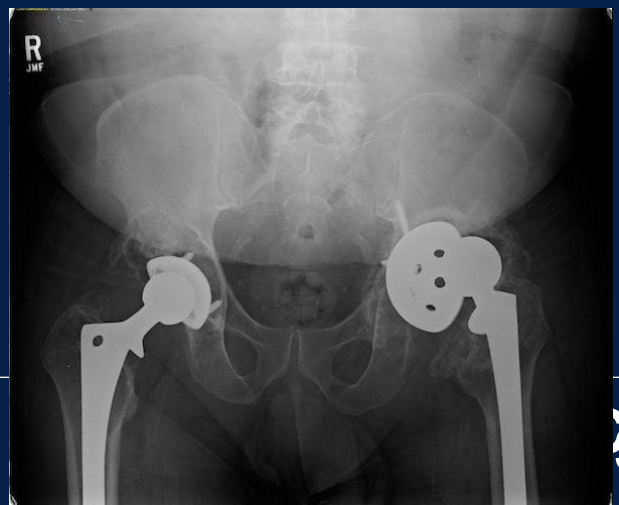
# Special Considerations

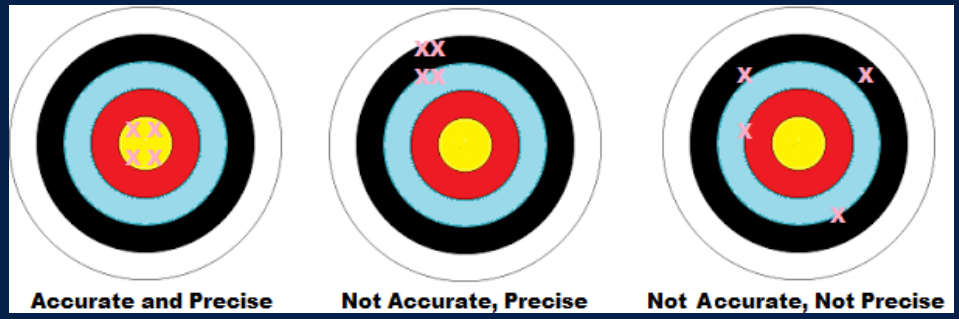
- DDH
  - RA-THA- improved HHS, ROM, and LLD from 17 to 4mm Vigdorchik Arthroplasty Today 2020
  - Improved accuracy of cup size/ position (96% vs 37%) Ueoka J Arthroplasty 2019, Chai Int Orthop 2022
- Hip fusion takedown Adil Arthroplasty Today 2021
  - Accuracy of cup position vs M-THA (87% vs 55%) Zhang J Arthroplasty 2022
- Obese Patients Zhang J Orthop Surg Res 2022
  - RA-THA improved restoration of hip COR and LLD
- Revision THA
  - Navigation improved positioning within combined anteversion targets (78% vs 48%) Kubota Clin Orthop Surg 2019, Chang J Arthroplasty 2017



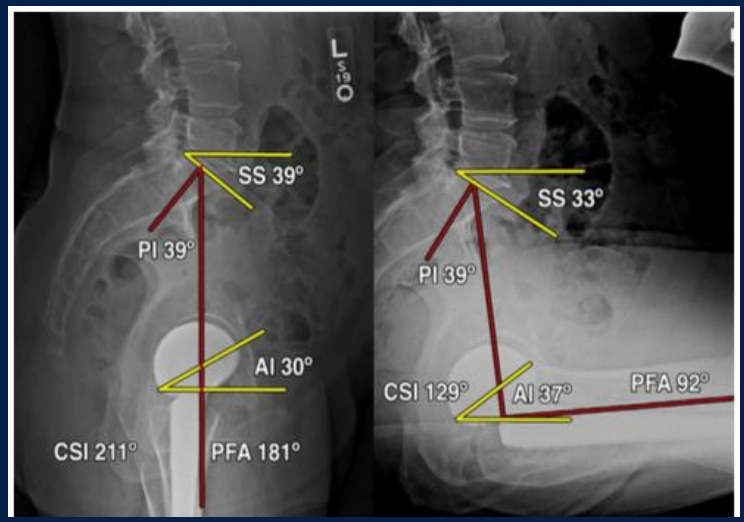
# “Functional Safe Zone”

- Accuracy vs Precision




- Increased awareness of hip-spine relationship
  - 90% late dislocations- spinopelvic imbalance

- Combined sagittal index (CSI) Tezuka J Arthroplasty 2019
  - Sagittal acetab (PI) + femur position (PFA) on sit/stand lateral XR



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# Financial Implications

- Direct Costs
  - Capital expenditures
  - Pre-op CT scan
  - Disposables
  - Maintenance

- Indirect Costs
  - Case length/ turnover time
  - Case cancellations due to pre-op imaging/ intra-op robotic issues

# Financial Implications

- Robot-
  - Disposables- $688-750/case
  - Maintenance- $400-600/case
- Accelerometer- [illegible]se

100 cases/year = $100,000



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# Economics of Robotics

- Nationwide Inpatient Sample- RA-THA, CA-THA and M-THA Emara Bone Joint J 2021
  - RA and CA-THA higher in hospital costs ($2,000)
- Medicare 100% data- 90d Episode of Care costs lower in RA-THA Pierce J Comp Eff Res 2021
  - $785 lower, due to dec utilization of post acute rehab services
- Markov Analysis Maldonado JAAOS 2021
  - RA-THA cost savings of $945 (Medicare) and $1,810 (Private)
  - RA-THA cost effective in 99.4% of cases
- Pearldiver Database Remily Arthroplasty Today 2021
  - RA-THA shorter LOS (3.4 vs 3.7d)
  - Mean cost of RA-THA $1684 and $1759 less at 90d and 1yr



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# Conclusions

- Technologic adjuncts in THA allow more reproducible component position and accurate restoration of patient anatomy
- Their impact on reducing complications and improving clinical outcomes remain to be seen
- Given the costs associated, further high quality, unbiased research is imperative prior to widespread adoption


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