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The March towards Digital Health: VR, AR, Artificial Intelligence

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Hoag Orthopedic Institute, Irvine CA

UCSF Arthroplasty for the Modern Surgeon, September 2022

Disclosures

- Stocks: Rzzr Medical
- Consultant:
  - Depuy-Synthes - Enabling Technologies
  - Rzzr Medical

Footnote: I am not a technophile nor an apologist for Technology

- Institutional Education and Research Support
  - OREF Omega Grant
  - The Hoag Foundation

- Own shares in a physician owned hospital

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GOAL

- Argue for benefit of incorporating **SOME** technology in our daily practice

- Review Current/Future trends in the use of the most ubiquitous technologies now

- Limited data in the literature

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Technology Transforming Healthcare

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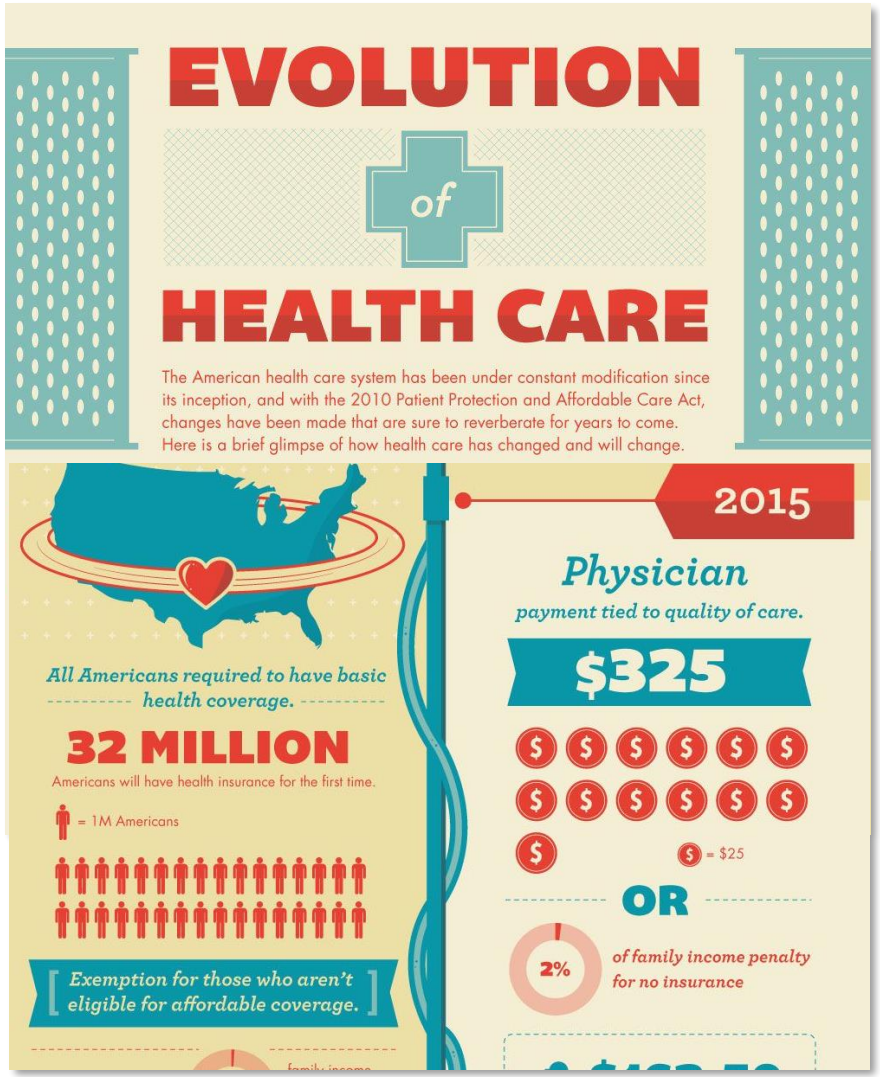
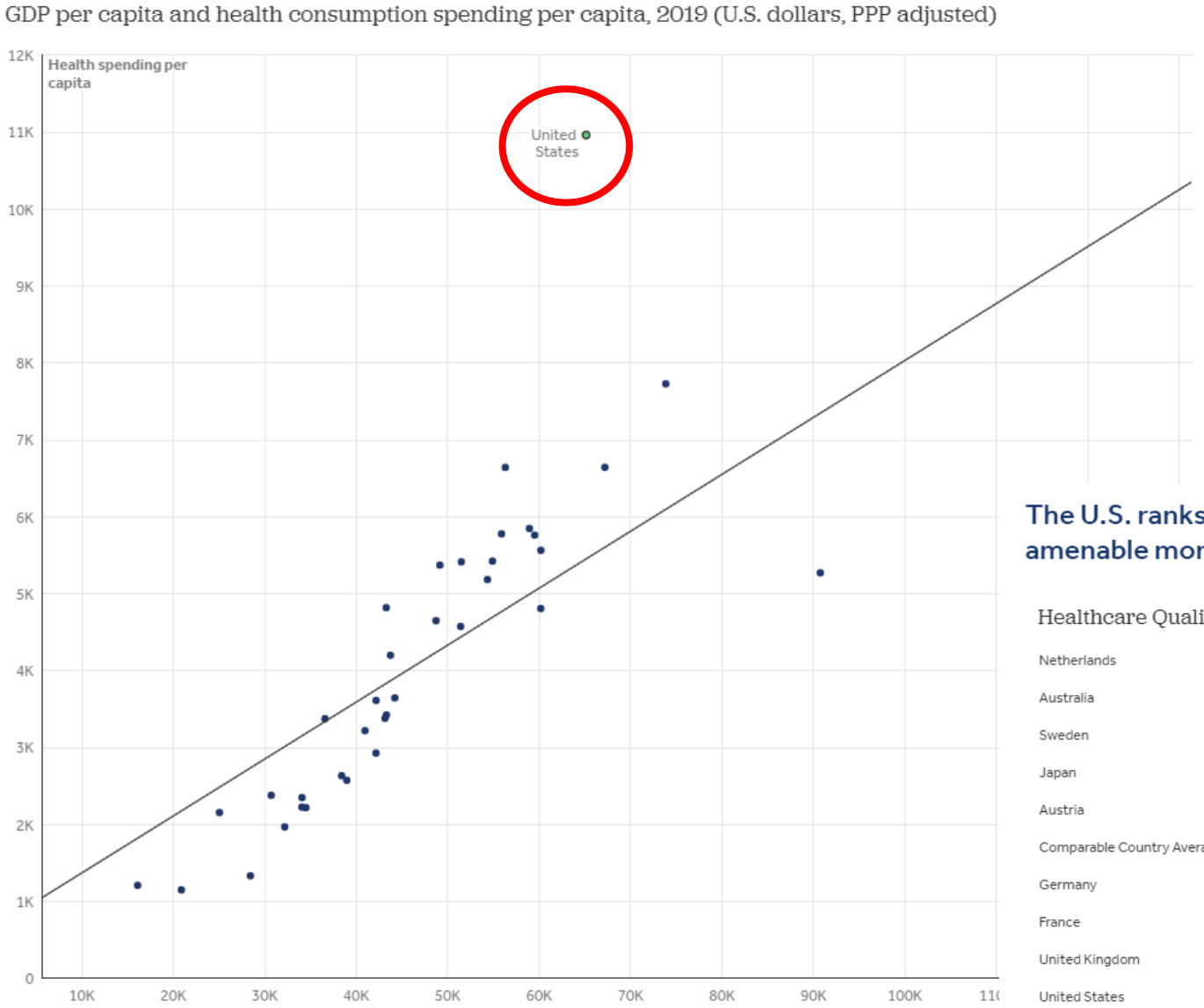
Why are technologies becoming more Relevant?

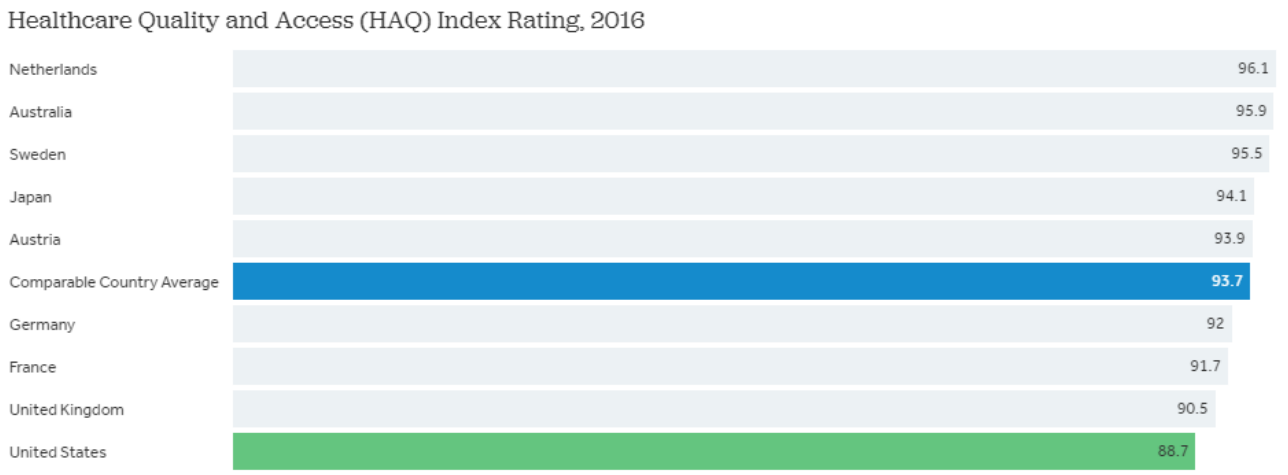


There is room for improvement in our healthcare system

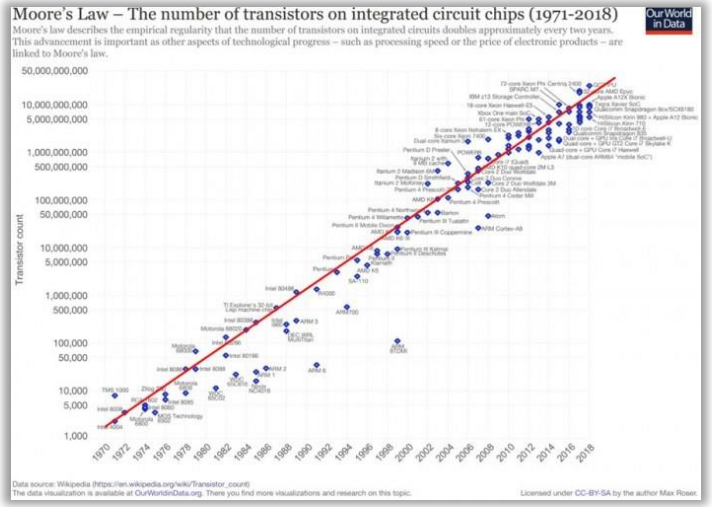


Quantity ≠ Quality

The U.S. ranks last in a measure of health care access and quality, indicating higher rates of amenable mortality than peer countries



Factors driving/enabling Technology Adoption



- Improved Computing capacity
- data analytics → improves decision support

- Transition to the outpatient setting
- Need to be able to do more with less space

- Technology is becoming cheaper
- more accessible (hololens, occulus)

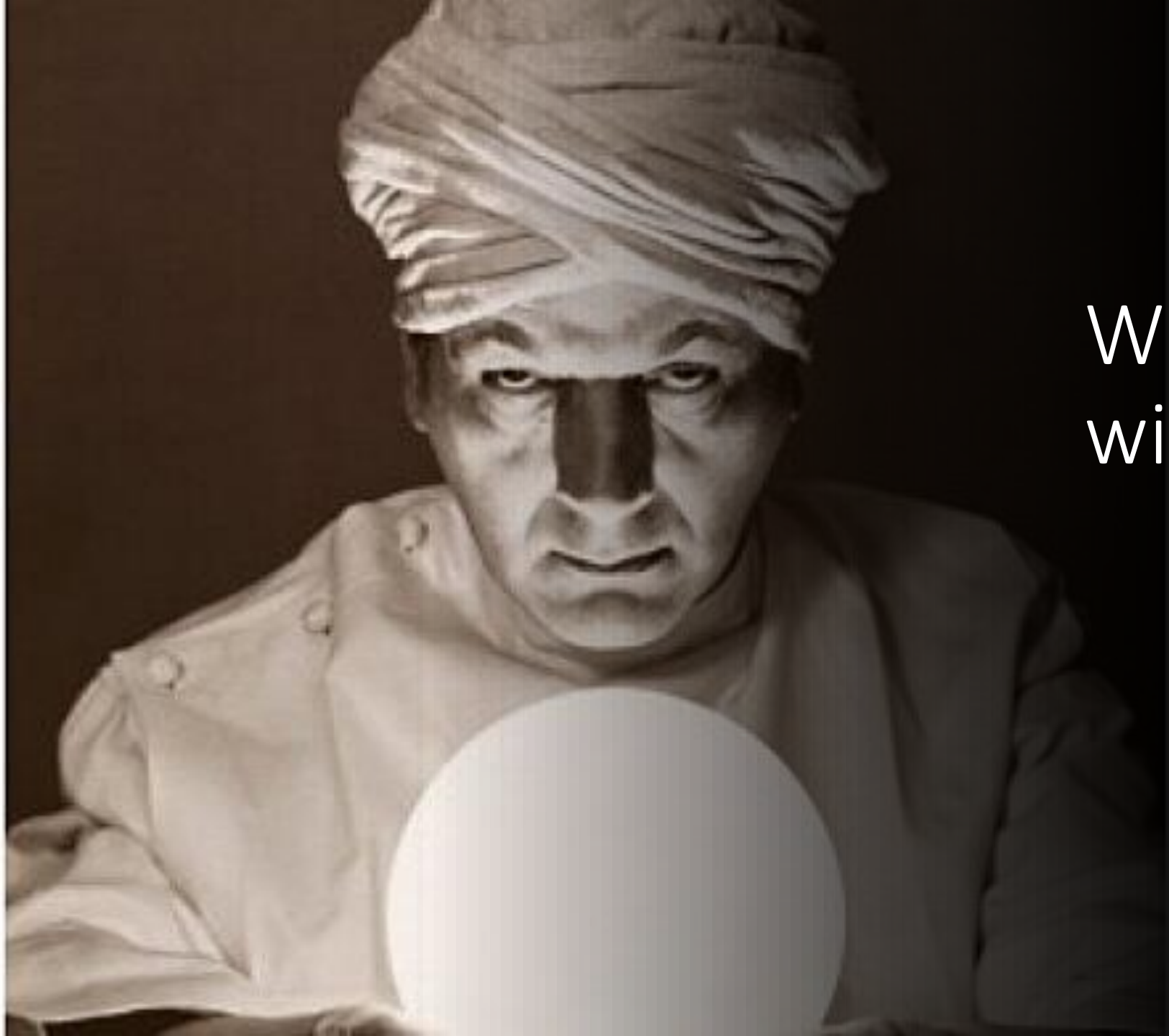
- Pressure to decrease costs.
- Labor Shortages
- Regulatory Pressures

Barriers against Technology adoption

Cost (Disposables, OR Time, capital Expenditures

Artificially created need

New toy/old toy phenomenon



Which Technology will win?


QUALITY
LEVEL
LOW
EXCELLENT +

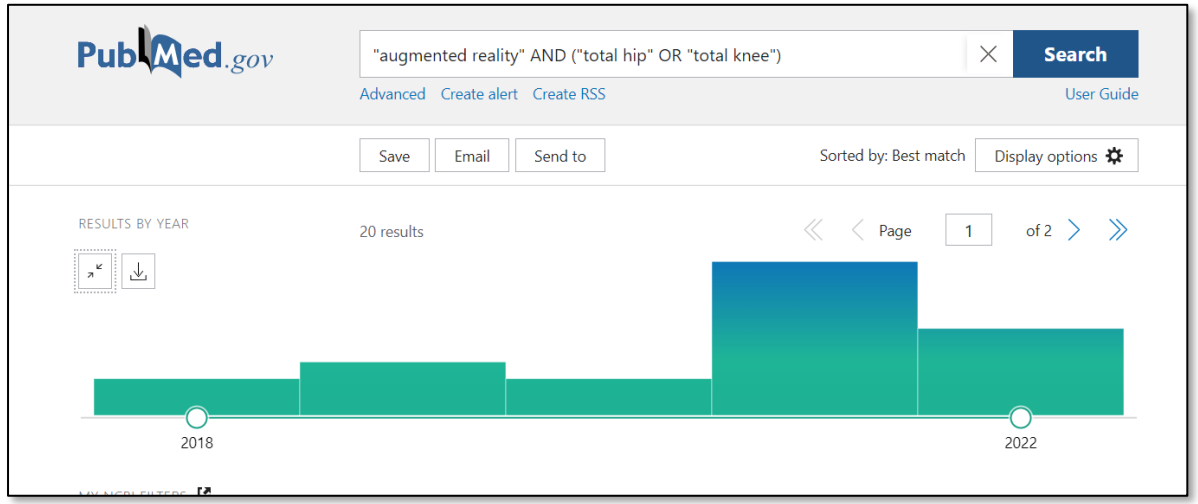

the
PRice
is
Right

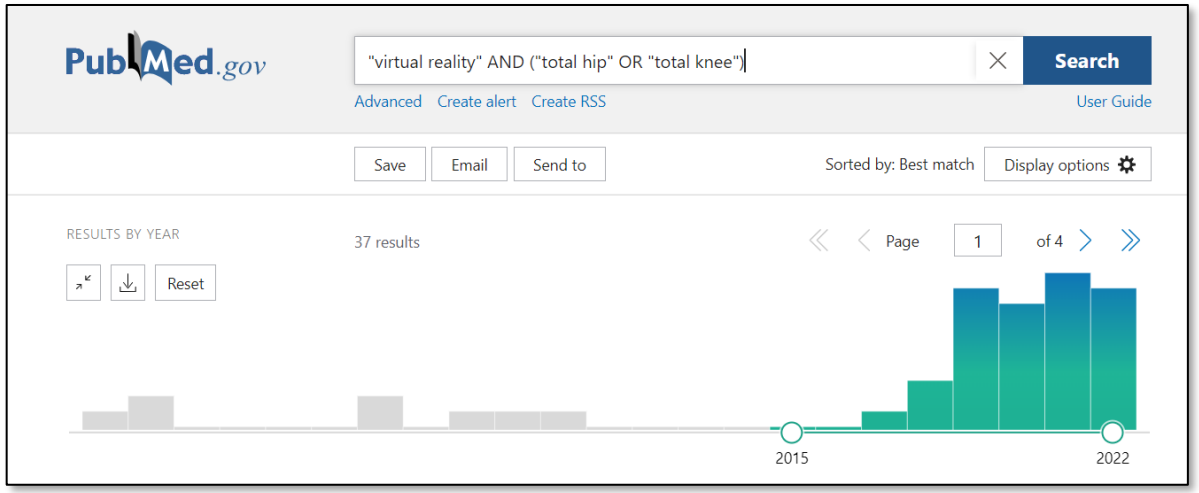

easy
STAPLES

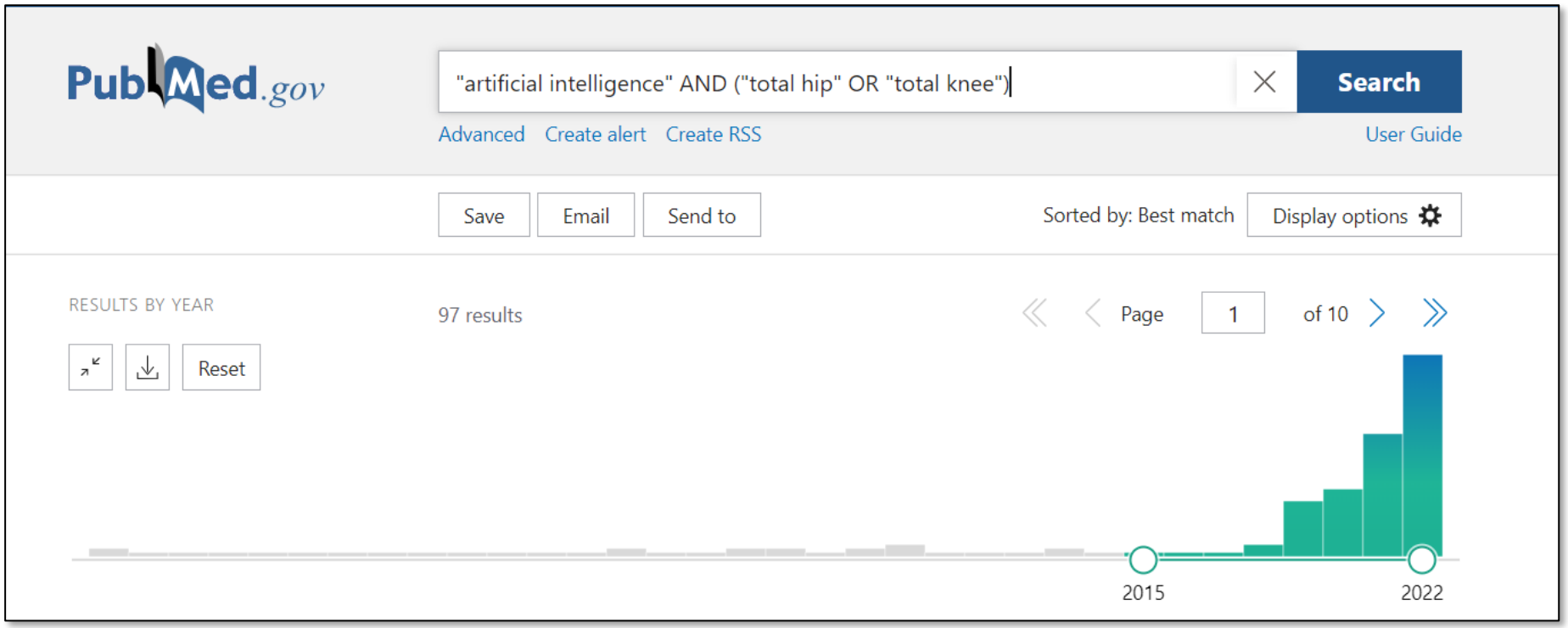
Technology embedded in the patient journey

- Preop (VR, AI)
- Intraop (AR, AI)
- Post op (VR, AI)

Evidence is not robust…but growing





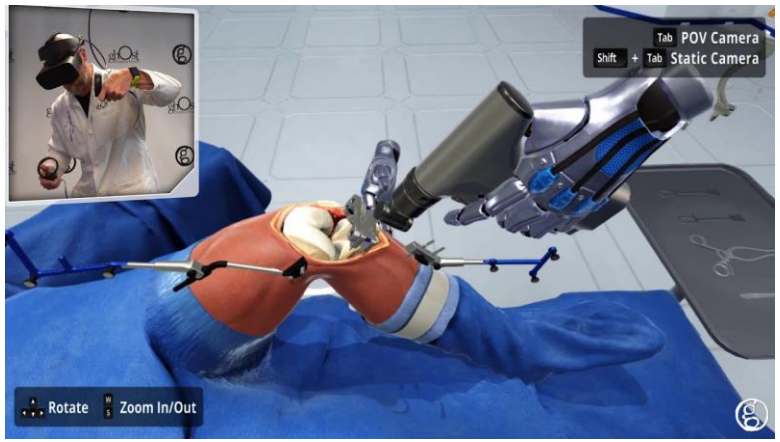


Virtual Reality (VR) - Definition

- **computer-generated simulation of a three-dimensional image** or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.

VR for surgical training

- Resident Work hour restrictions affect quality of resident training
- Allows for psychomotor training for the surgeons, residents and OR staff (scrub techs)
- Supports and reinforces neuromuscular training
- Reduces procedures Error Rates
- Literature supports that skills acquired in VR translate into real life applications



Logishetty *et al* JBJS AM 2020

- PGY 1-4 Residents trained on a Fully Immersive VR headset to perform DA THA
- Evaluated for objective improvements in consecutive sessions for procedural sequence, movement efficiency, duration of surgery, precision of acetabular component placement and femoral neck osteotomy.
- Evaluated translation to real life (Sawbones models)
- **Results:**
  - Average of 4 sessions to plateau and 10 sessions for expert level
  - 79% reduction in procedural errors
  - 70% reduction in verbal prompts
  - 28% reduction in duration of surgery.
  - 30% reduction in hand movement

Hooper *et al* JOA 2019

- 14 PGY-1, randomized and evaluated with pre and post VR cadaver THA
- Results:
  - Improved technical skills compared to the non VR group.

Archives of Orthopaedic and Trauma Surgery (2021) 141:2313–2321
https://doi.org/10.1007/s00402-021-04050-4

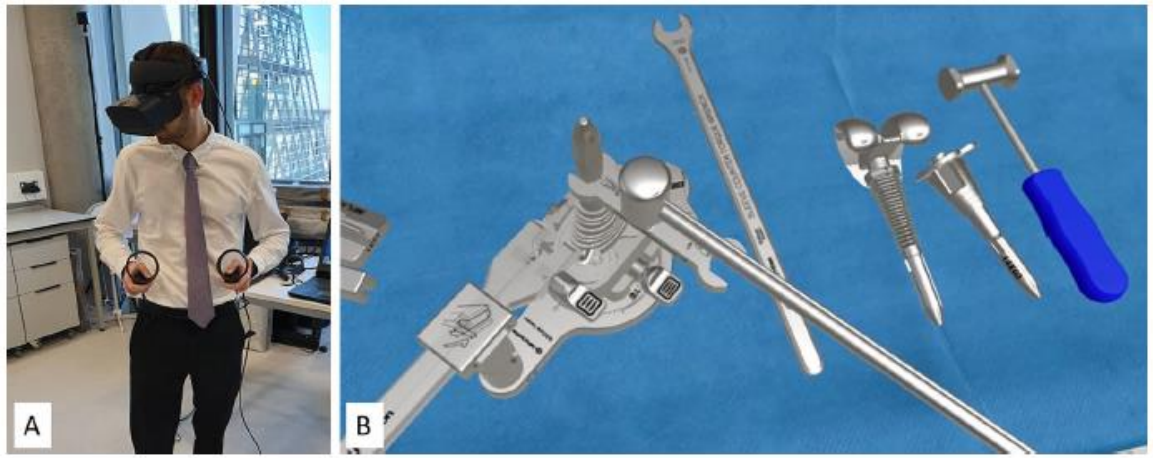
KNEE REVISION SURGERY

Check for updates

Immersive virtual reality enables technical skill acquisition for scrub nurses in complex revision total knee arthroplasty

Thomas C. Edwards[1,2] · Arjun Patel[1,2] · Bartosz Szyszka[1] · Alexander W. Coombs[1] · Alexander D. Liddle[1] · Rakesh Kucheria[2] · Justin P. Cobb[1] · Kartik Logishetty[1,2]

- 10 scrub nurses – 4 VR sessions
- Results:
  - 47% reduction in OR time
  - 75% reduction in verbal prompts
  - 30% reduction in hand motion



VR for pain control and anesthesia

RESEARCH ARTICLE

Effects of immersive virtual reality therapy on intravenous patient-controlled sedation during orthopaedic surgery under regional anesthesia: A randomized controlled trial

Mark Y. Huang[1¤a]*, **Simon Scharf**[1], **Peter Y. Chan**[2¤b]

1 Department of Anaesthesia and Acute Pain Medicine, St Vincent's Hospital Melbourne, Fitzroy, Victoria, Australia, 2 Department of Critical Care Medicine, St Vincent's Hospital Melbourne, Fitzroy, Victoria, Australia

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¤b Current address: Department of Intensive Care Medicine, Eastern Health, Box Hill, Victoria, Australia
* mark.yn.huang@gmail.com

NO DIFFERENCE

al of Anesthesiology

Virtual reality distraction decreases routine intravenous sedation and procedure-related pain during preoperative adductor canal catheter insertion: a retrospective study

Pooja G. Pandya[1], T. Edward Kim[1,2], Steven K. Howard[1,2], Erica Stary[1,2], Jody C. Leng[1,2], Oluwatobi O. Hunter[2], and Edward R. Mariano[1,2]

[1]*Department of Anesthesiology, Perioperative and Pain Medicine, Stanford University School of Medicine,*
[2]*Anesthesiology and Perioperative Care Service, Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, USA*

Reduced need for IV sedation

Virtual Rehab/Tele-rehab

- MAY provide equivalent outcomes with fewer resources
- COVID Safe
- Allows for quality care in remote locations/medical deserts
- Balance and Gait training VR games can help reinforce traditional PT.

- Patients need to be technologically capable

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Virtual reality rehabilitation following total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials

Aaron Gazendam[1,2] · Meng Zhu[1] · Yaping Chang[1] · Steve Phillips[1] · Mohit Bhandari[1,2]

- 9 RCT with 835 patients
  - No differences in pain scores/outcomes
  - Equivalent outcomes
  - 1 study showed improved costs

Effects of early virtual reality-based rehabilitation in patients with total knee arthroplasty

A randomized controlled trial

Silvia Gianola, PT, MSc, PhD[a,*], Elena Stucovitz, Eng MSc[b], Greta Castellini, PT, MSc, PhD[a], Mariangela Mascali, MD[c], Francesco Vanni, PT[c], Irene Tramacere, PhD[d], Giuseppe Banfi, MD[e,f], Davide Tornese, MD[c]

RESEARCH ARTICLE

Technology-assisted rehabilitation following total knee or hip replacement for people with osteoarthritis: a systematic review and meta-analysis

Xia Wang[1*], David J. Hunter[1,2], Giovana Vesentini[1,2], Daniel Pozzobon[1] and Manuela L. Ferreira[1]

Augmented Reality (AR) - Definition

- **A superimposed computer-generated image on a user's view of the real world**, thus providing a composite view with additional computer generated data.

Intraoperative Navigation with AR

- Alternative to traditional navigation
- No physical footprint
- No disposables
- Visual aberrations may compromise accuracy

Iacono et al. J EXP ORTOP (2021) 8:52
https://doi.org/10.1186/s40634-021-00374-7

Journal of
Experimental Orthopaedics

ORIGINAL PAPER Open Access

The use of augmented reality for limb and component alignment in total knee arthroplasty: systematic review of the literature and clinical pilot study

V. Iacono[1], L. Farinelli[2], S. Natali[1*], G. Piovan[1], D. Screpis[1], A. Gigante[2] and C. Zorzi[1]

Tsukada et al. Journal of Experimental Orthopaedics (2019) 6:44
https://doi.org/10.1186/s40634-019-0212-6

Journal of
Experimental Orthopaedics

RESEARCH Open Access

Augmented reality-based navigation system applied to tibial bone resection in total knee arthroplasty

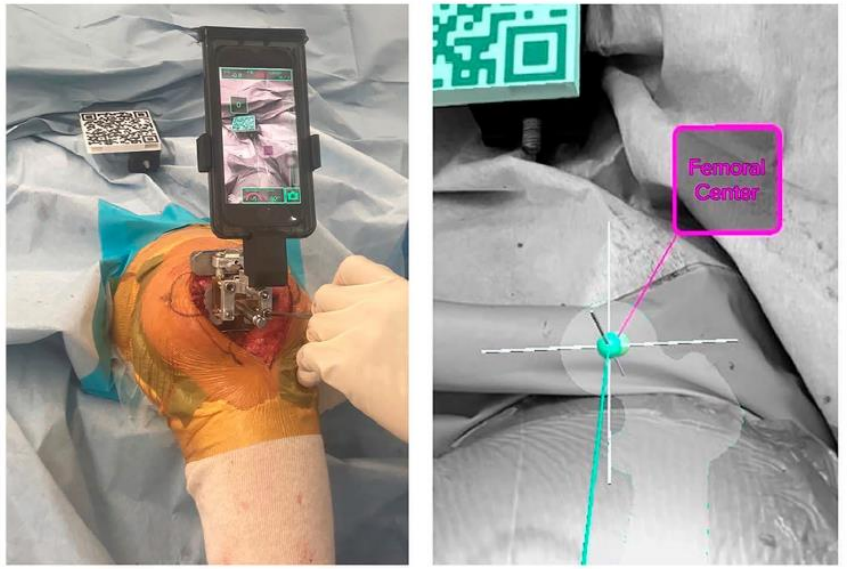
Sachiyuki Tsukada, Hiroyuki Ogawa*, Masahiro Nishino, Kenji Kurosaka and Naoyuki Hirasawa

Augmented Reality-Assisted Femoral Bone Resection in Total Knee Arthroplasty

Sachiyuki Tsukada, MD, PhD, Hiroyuki Ogawa, MD, Masahiro Nishino, MD, Kenji Kurosaka, MD, and Naoyuki Hirasawa, MD, PhD

Investigation performed at the Department of Orthopaedic Surgery, Hokusuikai Kinen Hospital, Mito, Japan

JBJS 2021



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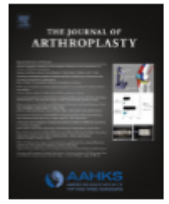
AR for Acetabular Component Positioning

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

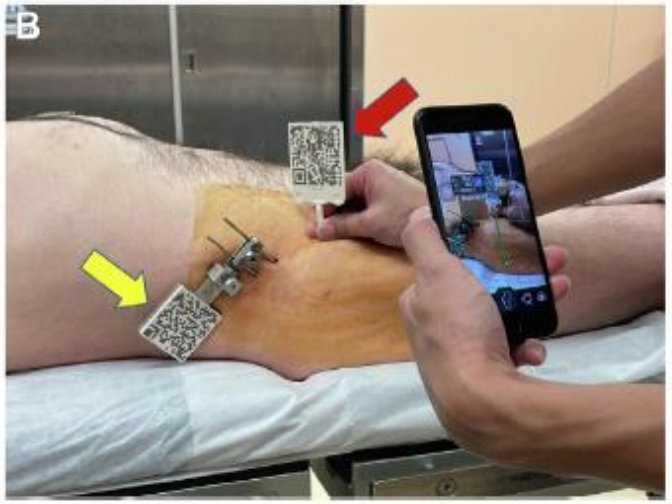


Primary Hip

Augmented Reality- vs Accelerometer-Based Portable Navigation System to Improve the Accuracy of Acetabular Cup Placement During Total Hip Arthroplasty in the Lateral Decubitus Position

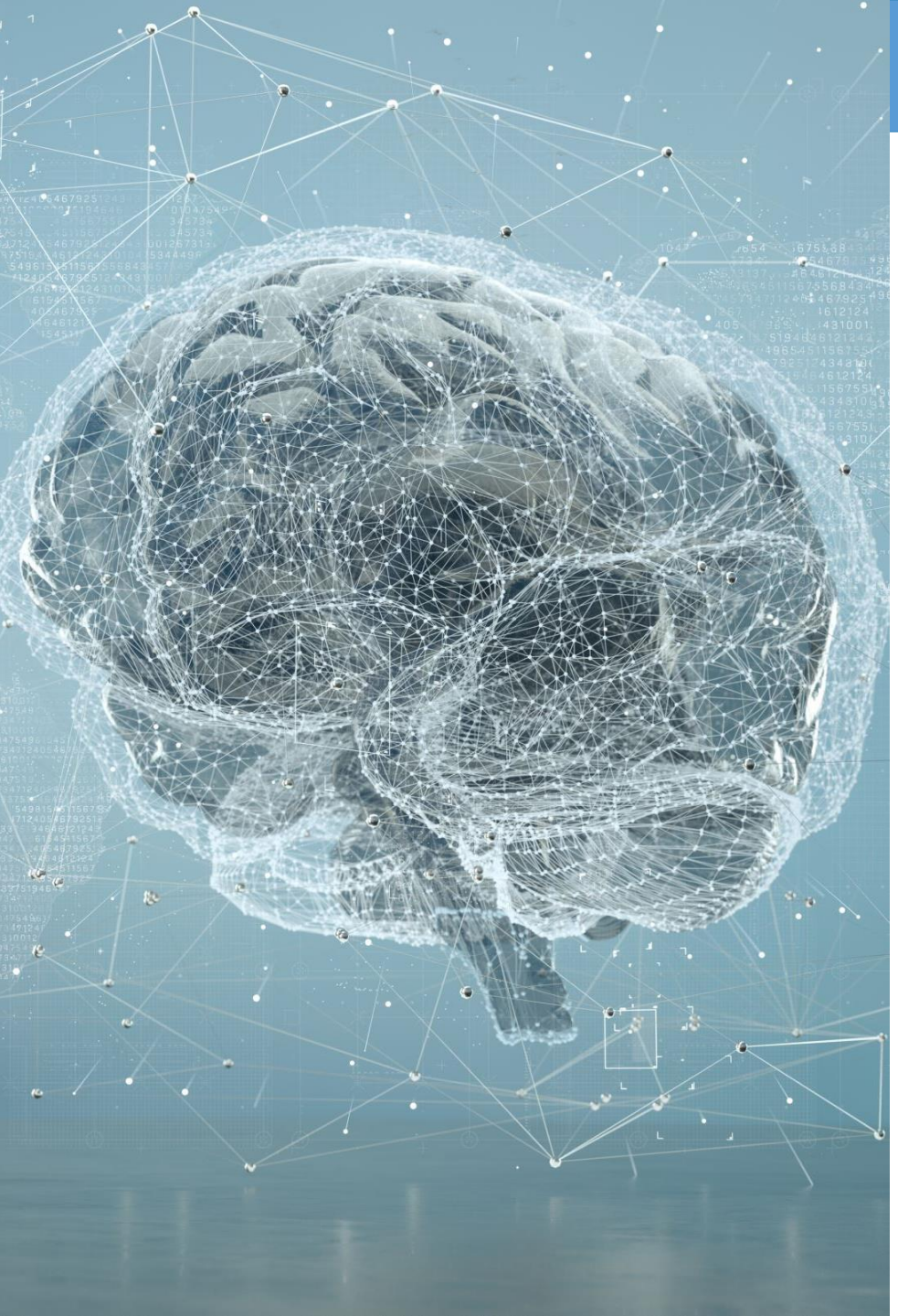
Sachiyuki Tsukada, MD, PhD, Hiroyuki Ogawa, MD *, Naoyuki Hirasawa, MD, PhD, Masahiro Nishino, MD, Hiromichi Aoyama, MD, Kenji Kurosaka, MD

Department of Orthopaedic Surgery, Hokusuikai Kinen Hospital, Ibaraki, Japan



AR for Intraoperative surgical support

- Reduces need for personnel in the OR
- Allows for remote access to help
- Potential for remote mentoring/preceptorships



Artificial Intelligence (AI) - Definition

Development of computer systems able to perform tasks that normally require human intelligence, such as **visual perception**, speech recognition, **decision-making**, and translation between languages.

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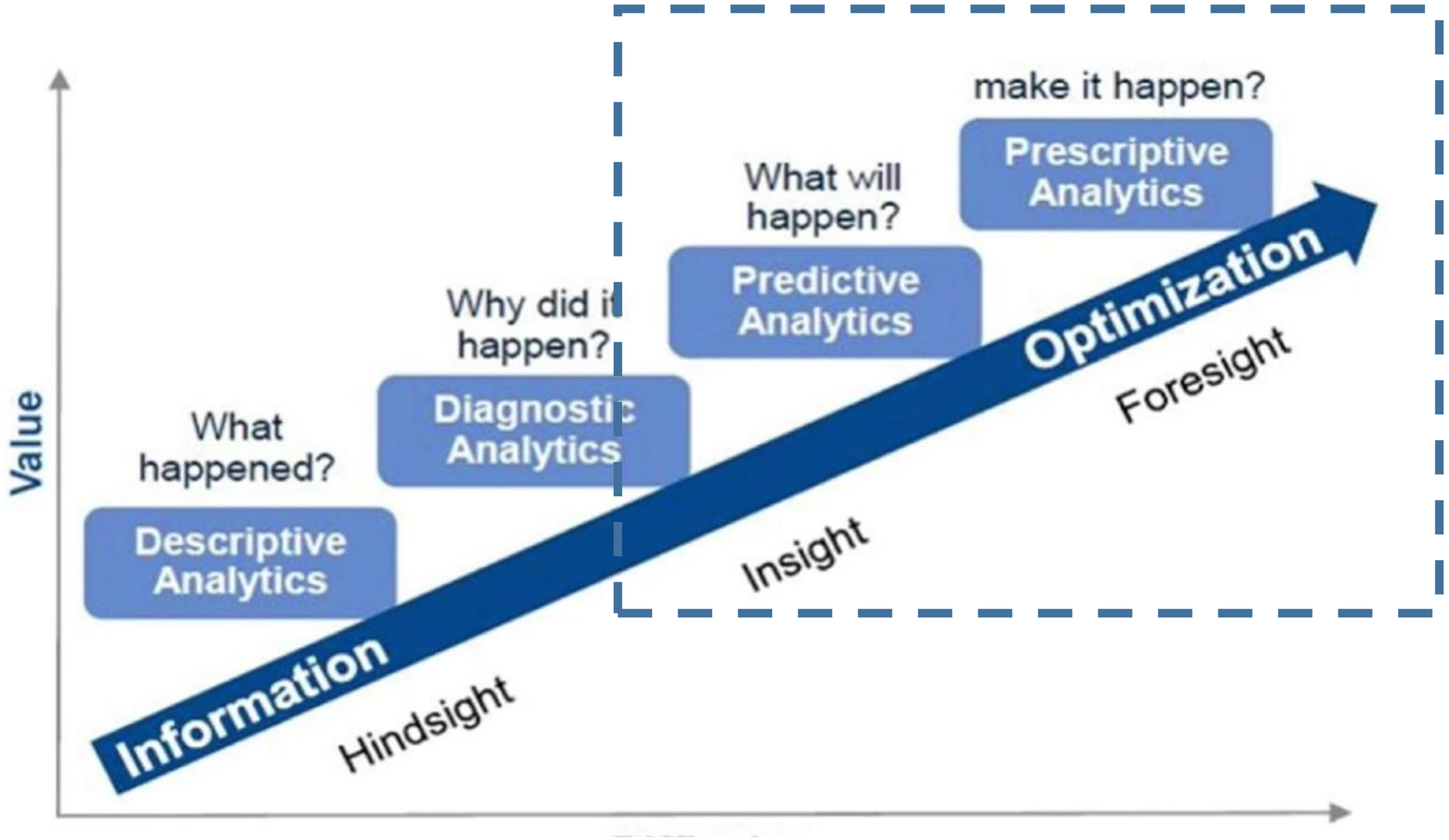
The Evolution of AI through Big Data



Artificial Intelligence: Patient Selection/Risk Stratification

The Viability of an Artificial Intelligence/Machine Learning Prediction Model to Determine Candidates for Knee Arthroplasty

David J. Houserman, DO [a, *], Keith R. Berend, MD [b, c],
Adolph V. Lombardi Jr., MD, FACS [b, c], Chanel E. Fischetti, MD [d], Erik P. Duhaime, PhD [e],
Anant Jain, MS [e], David A. Crawford, MD [b, c]

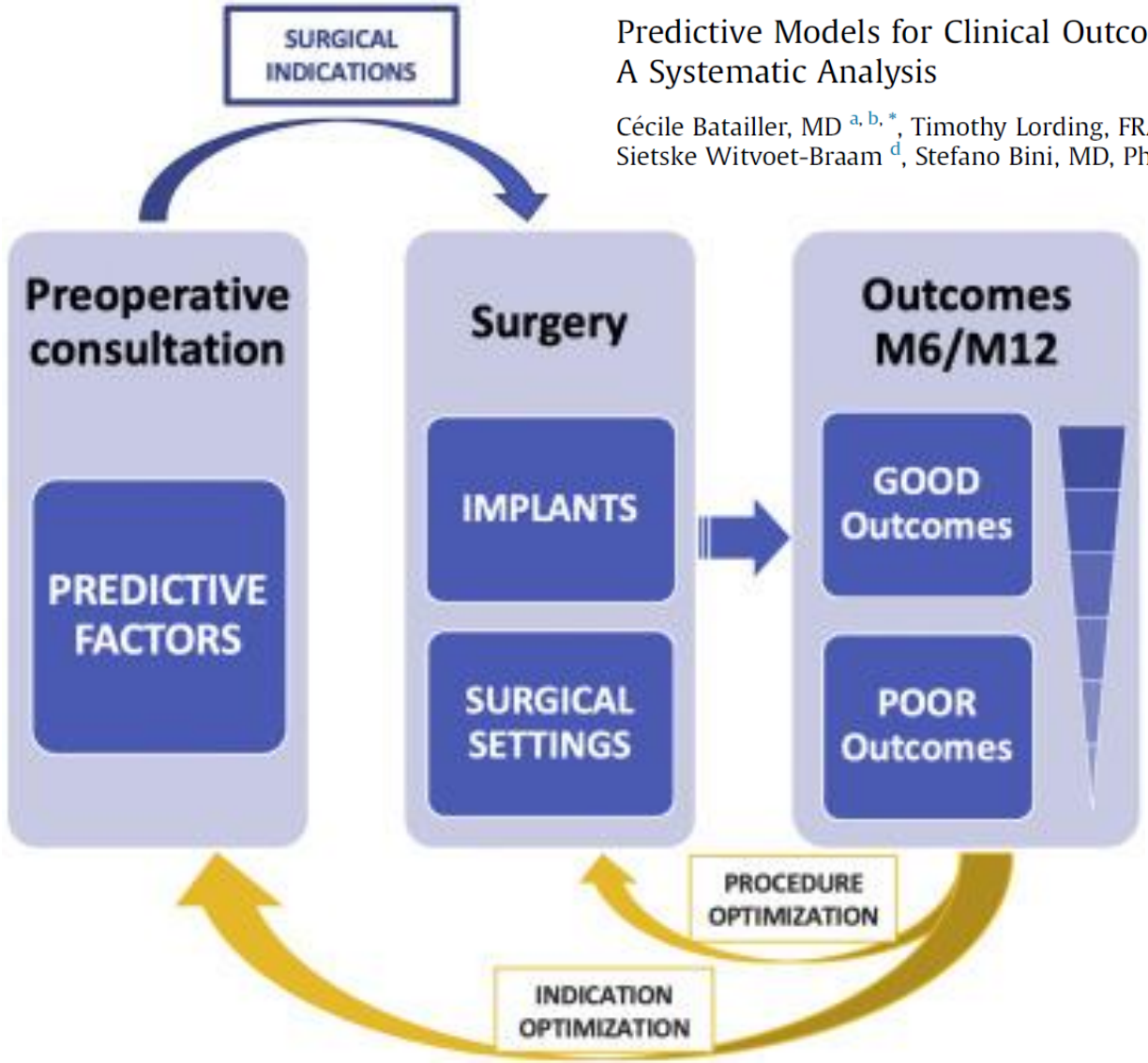
[a] *Department of Orthopedic Surgery, Kettering Health Network-Grandview Medical Center, Dayton, OH*
[b] *Joint Implant Surgeons, Inc, New Albany, OH*
[c] *Mount Carmel Health System, New Albany, OH*
[d] *Department of Emergency Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA*
[e] *Centaur Labs, Boston, MA*

Machine Learning Model Developed to Aid in Patient Selection for Outpatient Total Joint Arthroplasty

Cesar D. Lopez, MD, Jessica Ding, BA [*], David P. Trofa, MD, H. John Cooper, MD,
Jeffrey A. Geller, MD, Thomas R. Hickernell, MD

New York-Presbyterian/Columbia University Irving Medical Center, New York, NY, USA

Artificial Intelligence: Intraop Decision Support



Systematic review

Predictive Models for Clinical Outcomes in Total Knee Arthroplasty: A Systematic Analysis

Cécile Batailler, MD [a, b, *], Timothy Lording, FRACS [c], Daniele De Massari, PhD [d], Sietske Witvoet-Braam [d], Stefano Bini, MD, PhD [e], Sébastien Lustig, MD, PhD [a, b]

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Machine Learning Algorithms Identify Optimal Sagittal Component Position in Total Knee Arthroplasty

Hassan Farooq, BS [a], Evan R. Deckard, BSE [b], Nicholas R. Arnold, MD [c], R. Michael Meneghini, MD [b, d, *]

[a] *Indiana University School of Medicine, Indianapolis, IN*
[b] *Department of Orthopaedic Surgery, Indiana University School of Medicine, Indianapolis, IN*
[c] *Department of Orthopedic Surgery, Cleveland Clinic Foundation, Cleveland, OH*
[d] *Indiana University Health Hip & Knee Center, IU Health Saxony Hospital, Fishers, IN*

BJO

GENERAL ORTHOPAEDICS

The application of machine learning to balance a total knee arthroplasty

M. A. Verstraete, R. E. Moore, M. Roche, M. A. Conditt

St. Helena Hospital, Saint Helena, California, USA

Aims

The use of technology to assess balance and alignment during total knee surgery can provide an overload of numerical data to the surgeon. Meanwhile, this quantification holds the potential to clarify and guide the surgeon through the surgical decision process when selecting the appropriate bone recut or soft tissue adjustment when balancing a total knee. Therefore, this paper evaluates the potential of deploying supervised machine learning (ML) models to select a surgical correction based on patient-specific intra-operative assessments.

Methods

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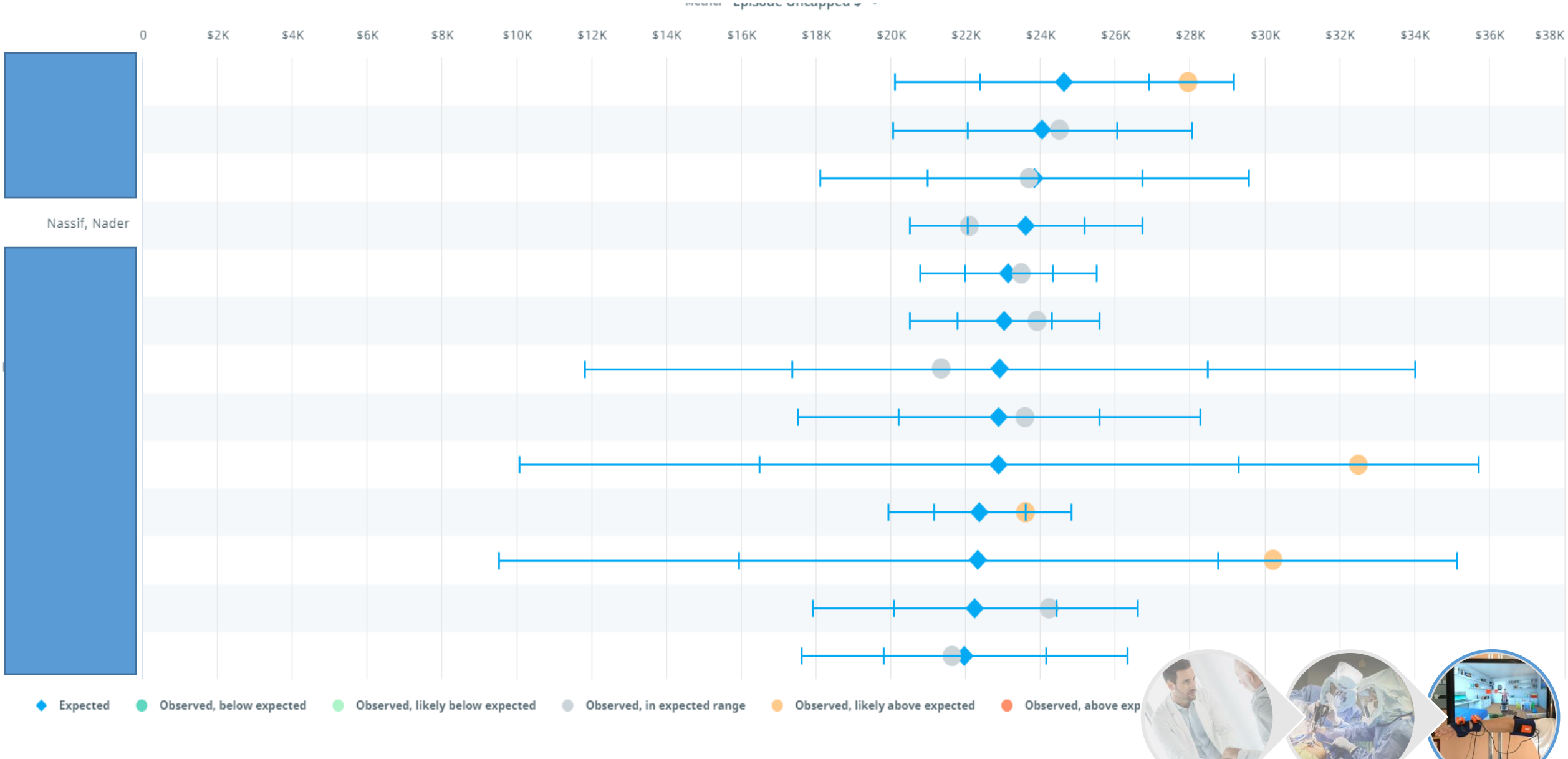
Predictive Analytics: Value Analysis



Artificial Intelligence: Predictive Analytics for Population Health Management

- LOS
- PROs
- Transfusion Rates, Complications
- Opioid Use
- Recurrent Infections following Replants

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Primary Knee

Development of Machine Learning Algorithms to Predict Patient Dissatisfaction After Primary Total Knee Arthroplasty

Kyle N. Kunze, MD *, Ev
Brett R. Levine, MD, MS

Division of Adult Reconstruction, Departr

Complications - Other

Deep Learning Artificial Intelligence Model for Assessment of Hip Dislocation Risk Following Primary Total Hip Arthroplasty From Postoperative Radiographs

Check for updates

Pouria Rouzrokh,
Cody C. Wyles, M
Michael J. Taunton
Bradley J. Erickson

[a] *Department of Radiology, Rad*
[b] *Department of Health Science*
[c] *Department of Orthopedic Su*

Artificial Intelligence and Machine Learning

Development of Machine Learning Algorithms for Prediction of Sustained Postoperative Opioid Prescriptions After Total Hip Arthroplasty

Aditya V. Karhade, BE

Department of Orthopedic Surgery, M

Health Policy & Economics

Development and Validation of a Machine Learning Algorithm After Primary Total Hip Arthroplasty: Applications to Length of Stay and Payment Models

Check for updates

Prem N. Ramkumar, MD, MBA [a,*], Sergio M. Navarro, MBA [b], Heather S. Haeberle, BS [c], Jaret M. Karnuta, BS [a], Michael A. Mont, MD [d], Joseph P. Iannotti, MD, PhD [a], Brendan M. Patterson, MD, MBA [a], Viktor E. Krebs, MD [a]

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[b] *Nuffield Department of Orthopaedics, Rheumatology, and M*
Kingdom
[c] *Department of Orthopaedic Surgery, Baylor College of Medic*
[d] *Department of Orthopaedic Surgery, Lenox Hill Hospital, Ne*

Complications - Other

Prediction Models for 30-Day Mortality and Complications After Total Knee and Hip Arthroplasties for Veteran Health Administration Patients With Osteoarthritis

Alex HS. Harris, PhD [a, b, *], Alfred C. Kuo, MD, PhD [c], Thomas Bowe, PhD [a], Shalini Gupta, MS [a], David Nordin, MD [d], Nicholas J. Giori, MD, PhD [a, e]

[a] *Center for Innovation to Implementation, VA Palo Alto Health Care System, Palo Alto, CA*
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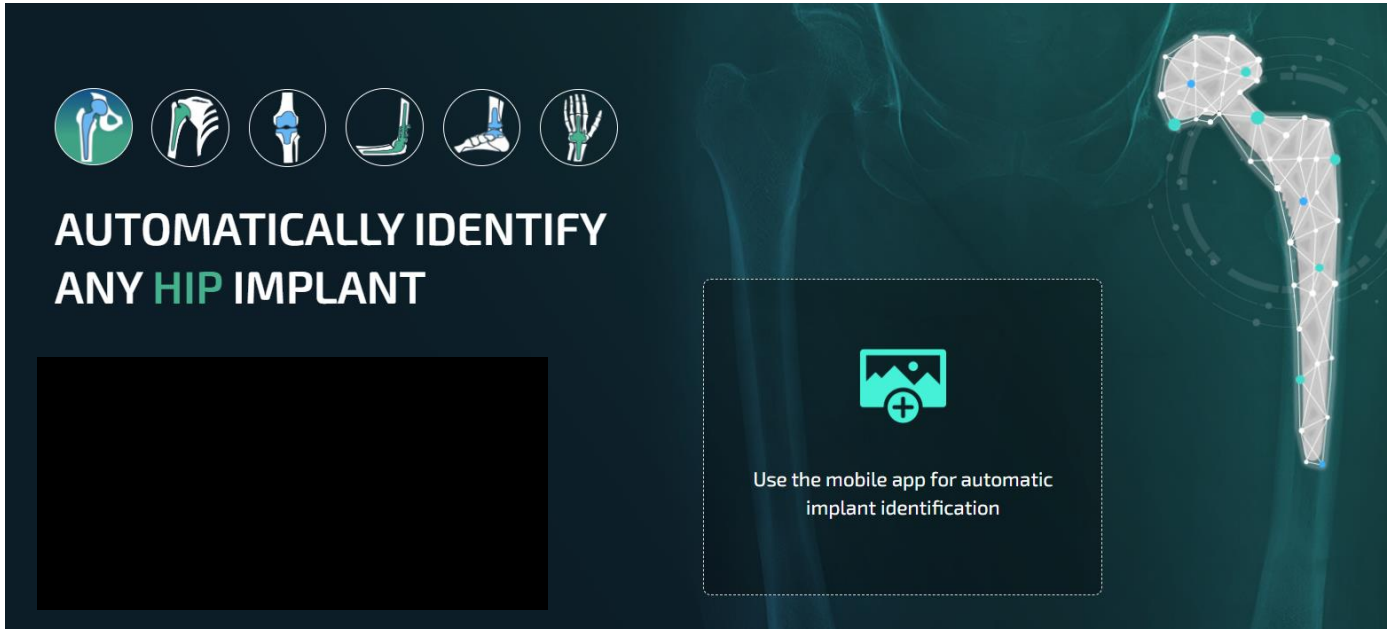
[e] *Department of Orthopedic Surgery, Stanford University School of Medicine, Stanford, CA*

Artificial Intelligence: Visual Intelligence/Image Analysis



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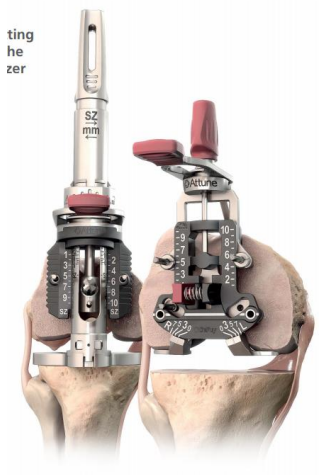
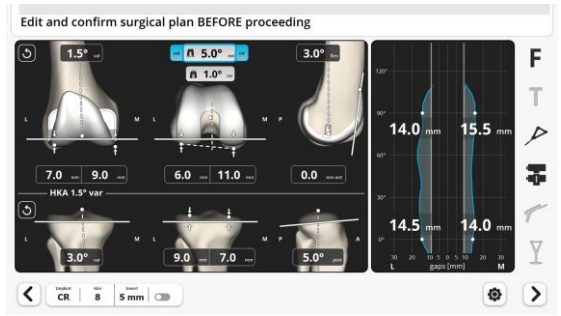
Past **Present** **Future**





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Thank you