The Asymptote to Utopia

Michael J Dunbar MD, FRCSC, PhD

Professor of Surgery, Biomedical Engineering, and
Community Health and Epidemiology
Dalhousie University

QE II Foundation Endowed Chair in Arthroplasty Outcomes

IMPACT
Dynamics of human motion Laboratory
Neuromuscular function Laboratory
Dalhousie University
Inspiring Minds

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Gullfoss
1
Selfoss
35
Veiði-
hús
Alviðra
36
350
Torfastaðir II
Torfastaðir I
Írafoss
Veiði
hús
Þing-
vellir
Litli-Háls
Bílds-
fell I-III
Stóri-Háls
Úlfljóts-
vatn
Hlíð
Sog
Úlfljótsskáli
Skátar
Selflatarrétt
Villingavatn
Krókur
Ölfusvatn
360
Hagavík
Þingvallavatn
Nesjar
Nesjavalla-
virkjun
Nesjavellir
Heiðarbær I
Heiðarbær II
Reykjavík
36
Þingvellir
Reykjavík

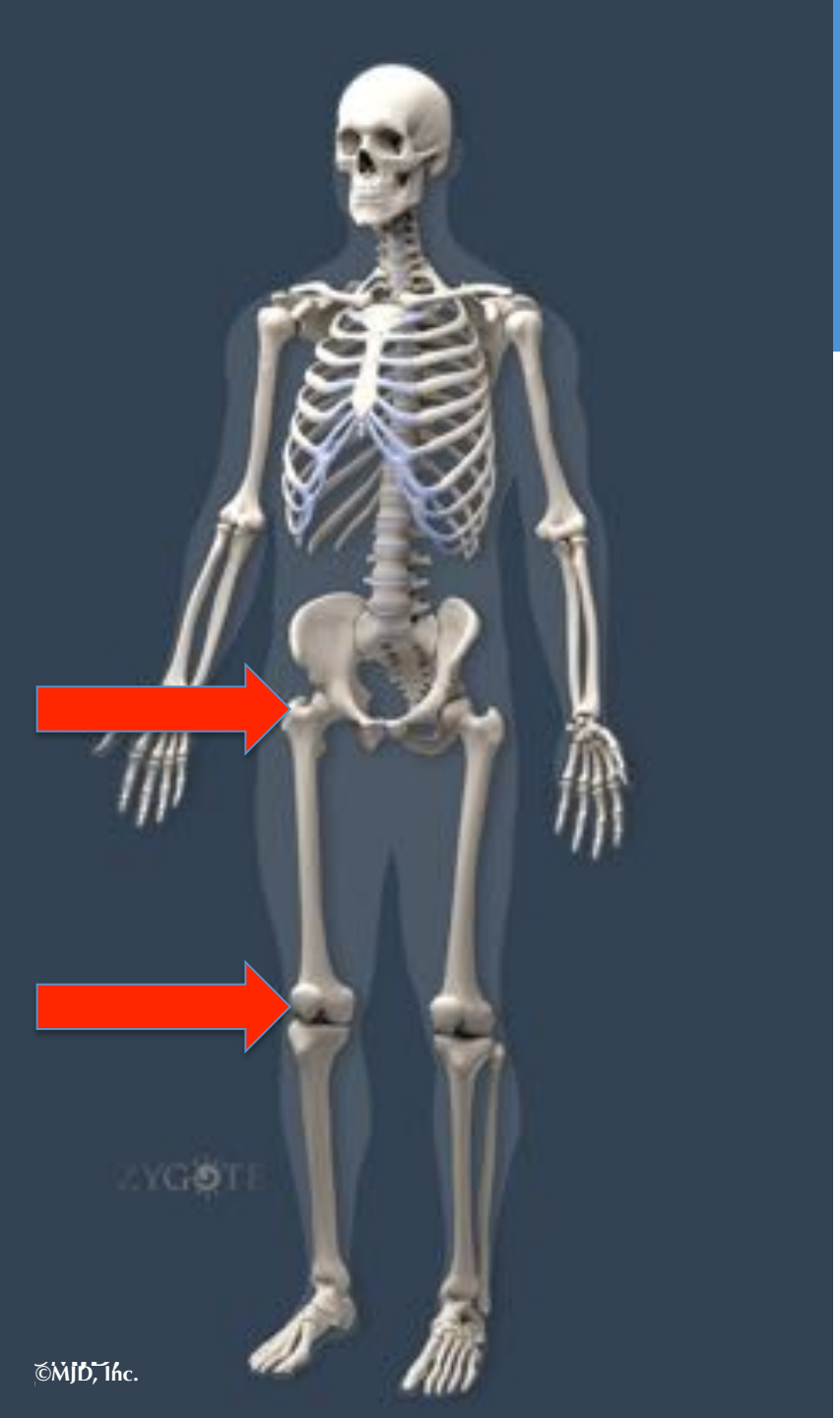
Arthroplasty

Arthron

Joint

Plastos

Formed/Molded



Types of Arthroplasty

- Hip
- Knee
- Shoulder
- Elbow
- Wrist
- Fingers/toes
- Ankle
- Spine

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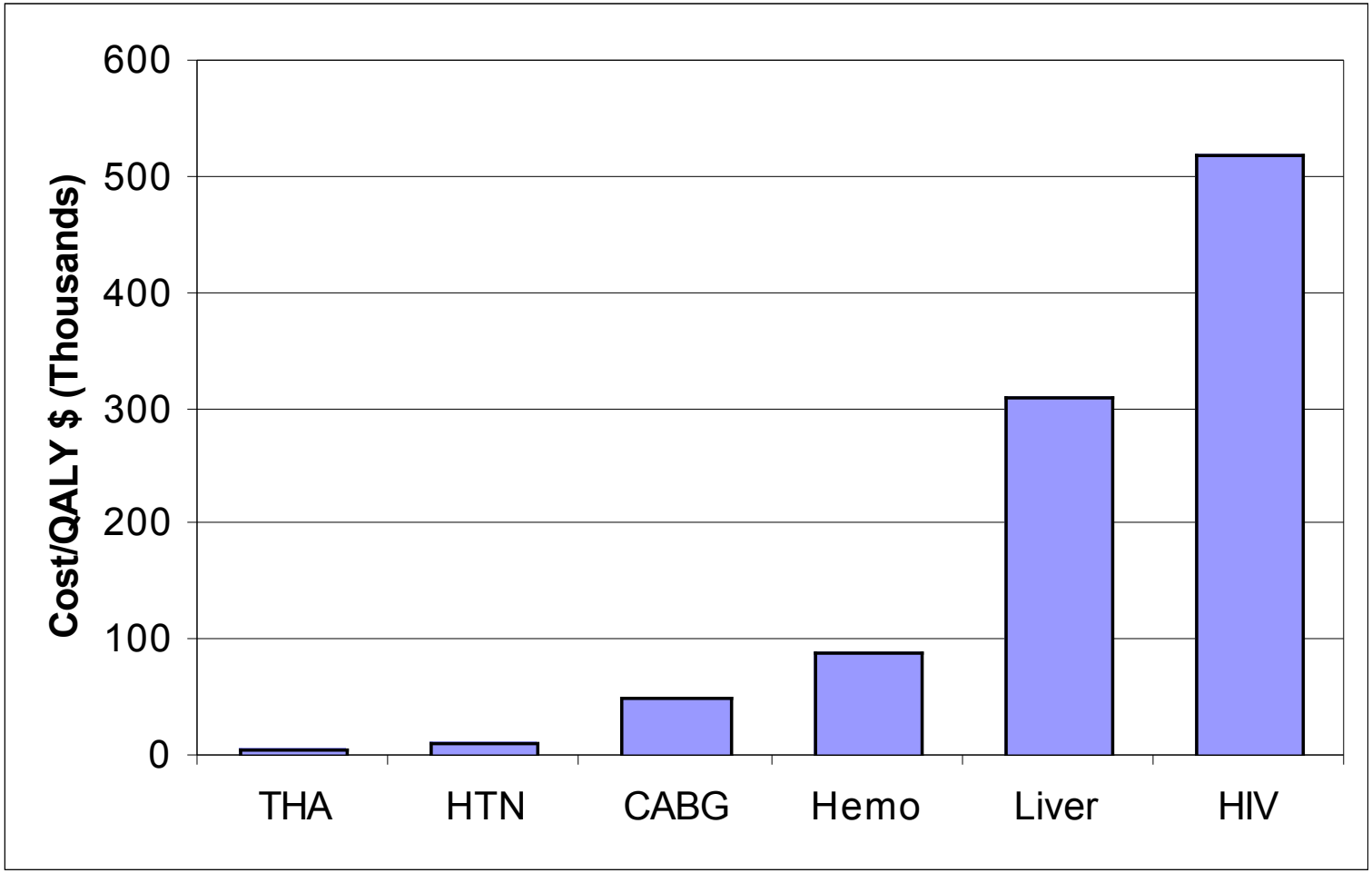
Ratio of Cost to Quality of Life Improvement by Procedure

Laupacis et al 1992



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The 5 National Priorities for Wait Times Reduction

- Hip and Knee Arthroplasty
- Cancer
- Cardiac
- Cataracts
- Diagnostic Imaging

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Asymptote to Utopia

Phase I

Phase II

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The Paradox of Arthroplasty Outcomes

Standard Effect Size

$$\frac{\text{(Post-op score - Pre-op score)}}{\text{SD Post-op score}}$$

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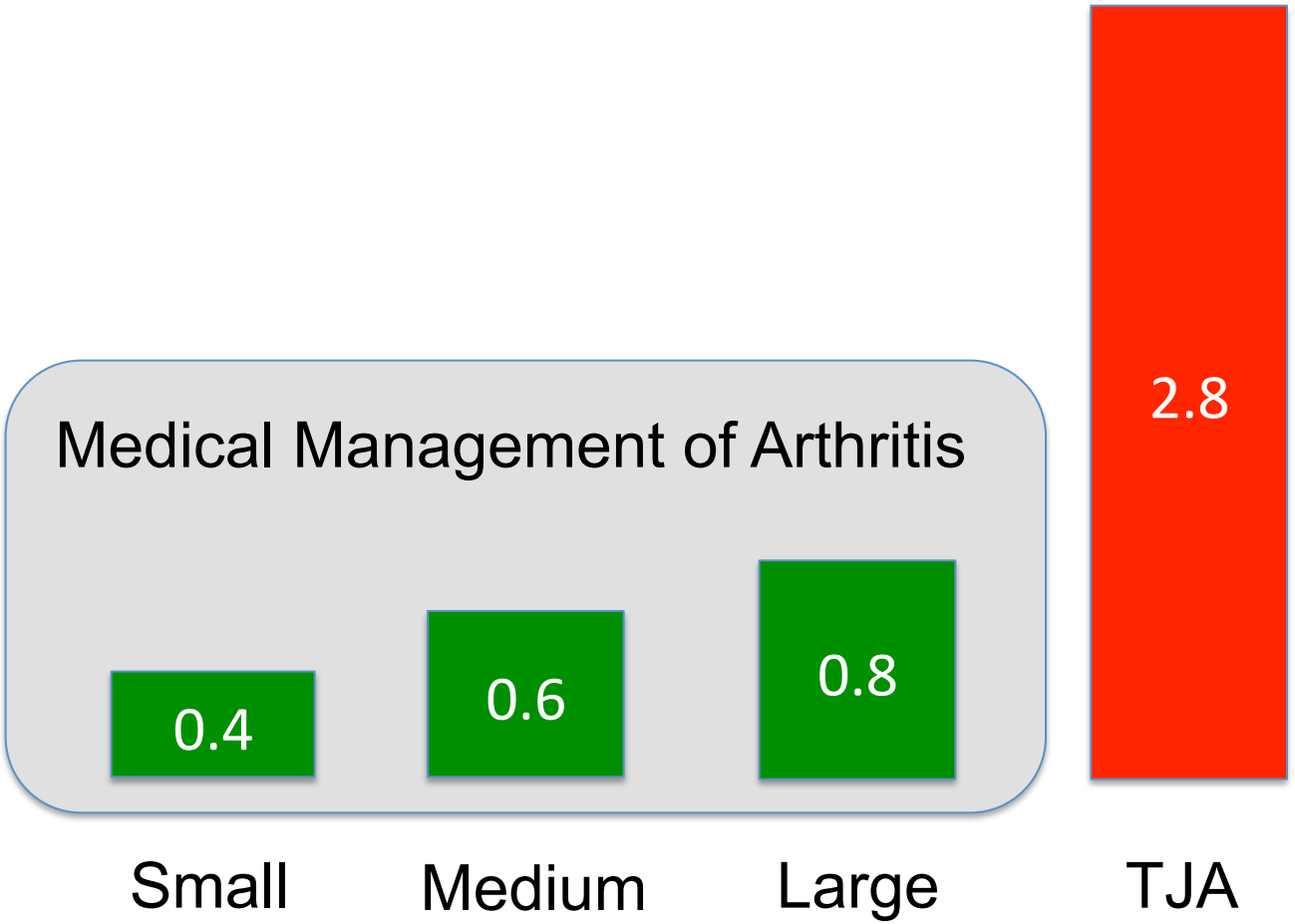
Standard Effect Size



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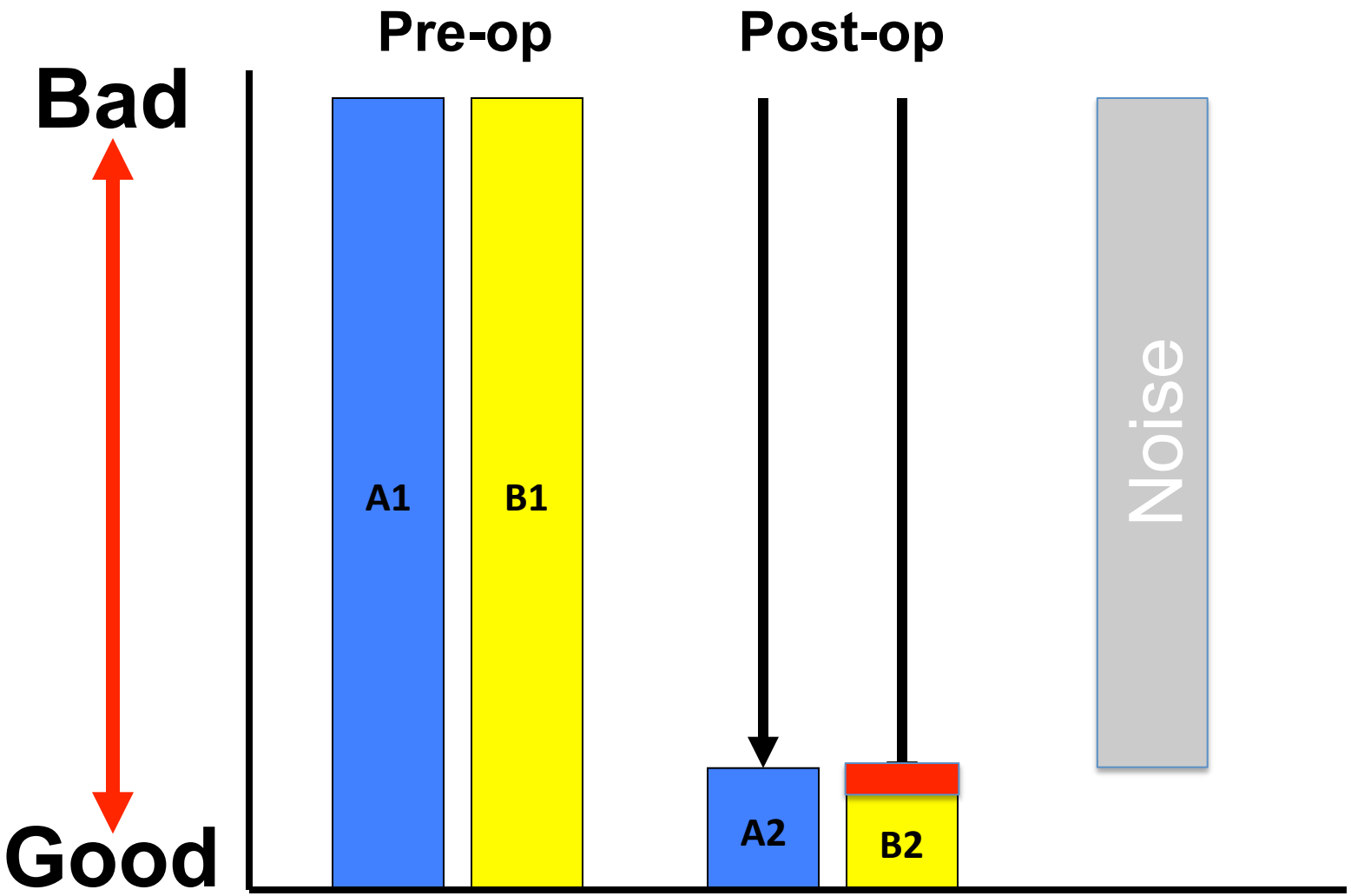
Health Outcome Questionnaires



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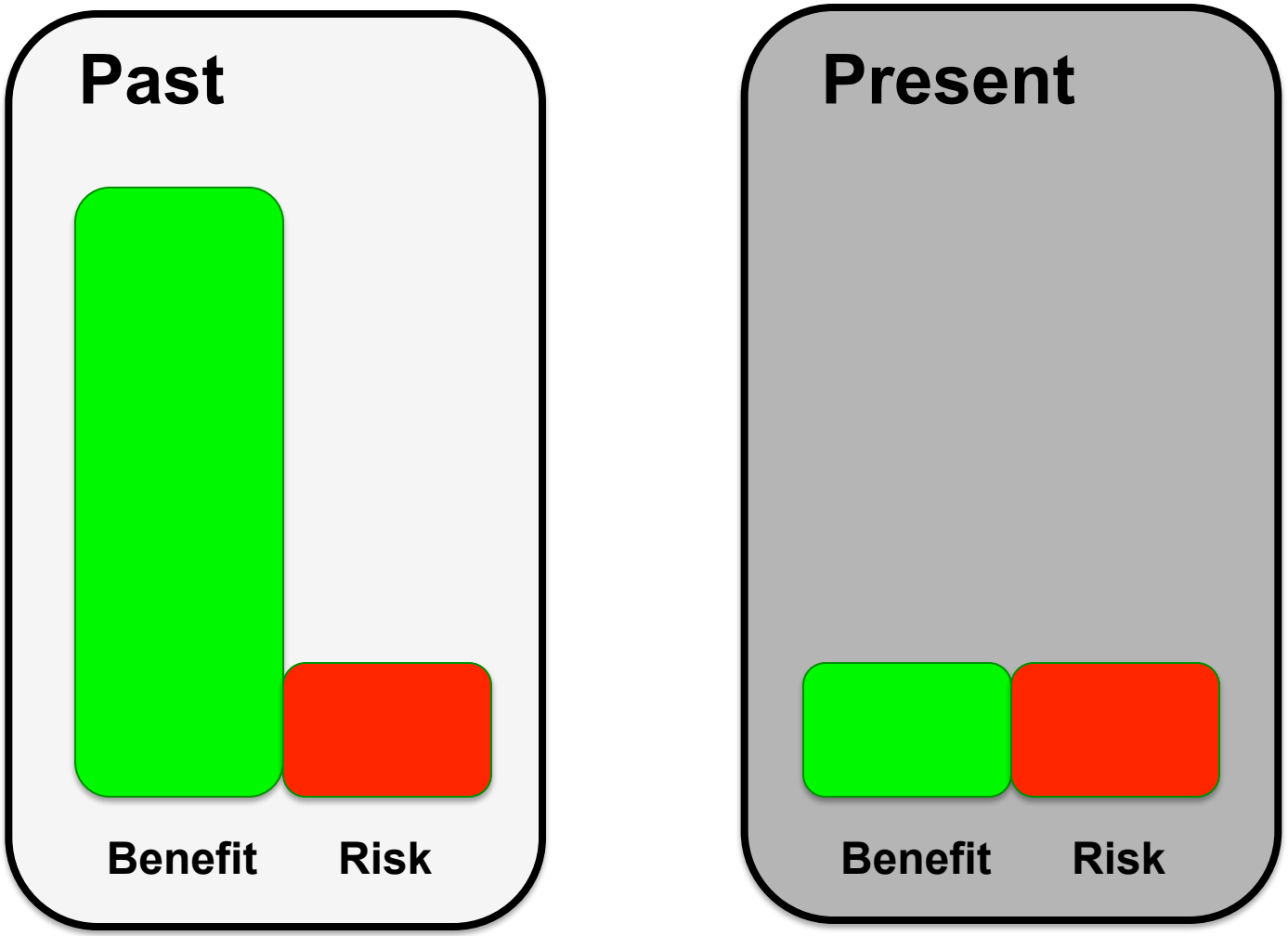
Risk-Benefit Ratio for Innovation



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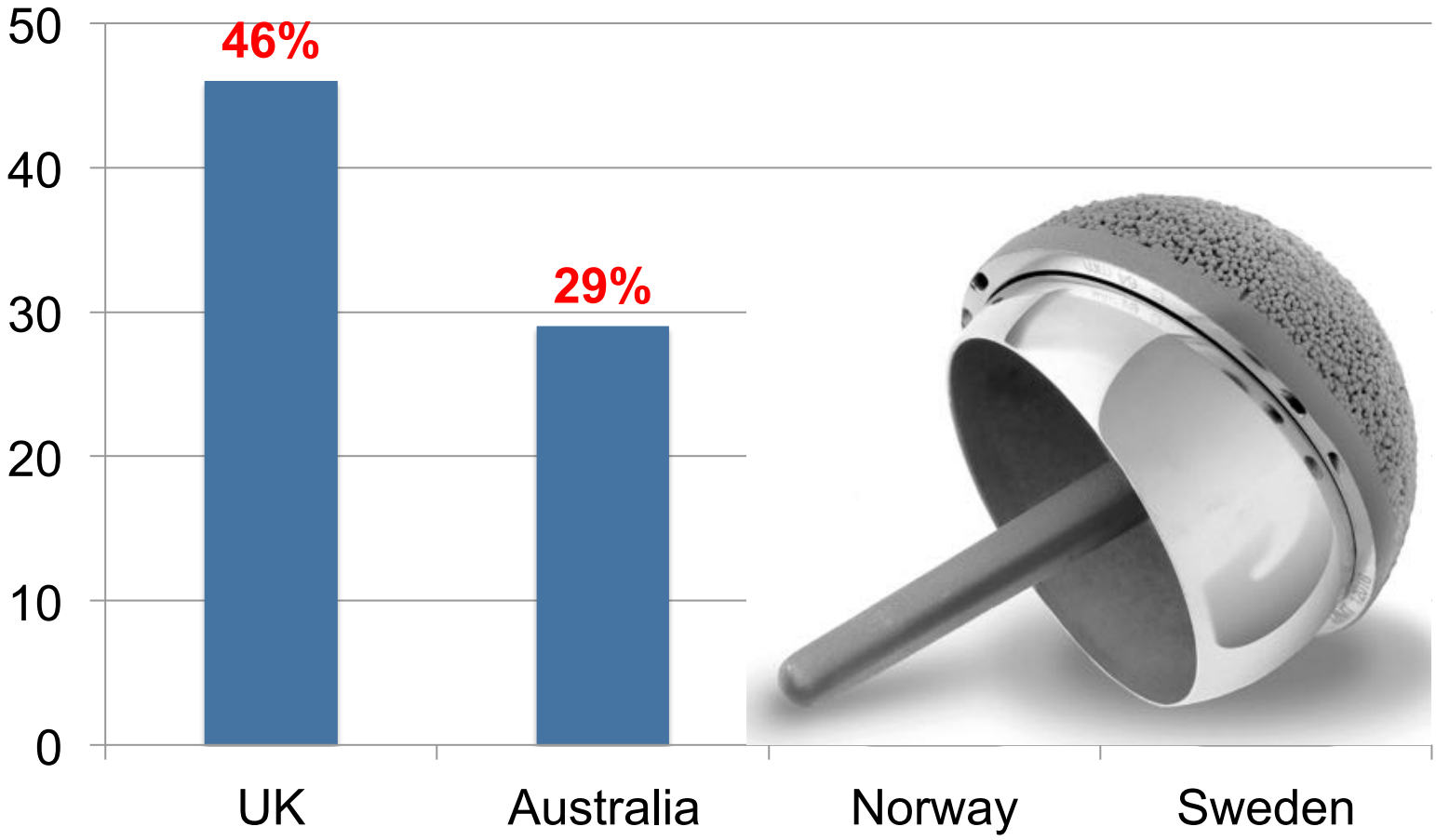
Percentage of Hip Replacements in Patients <55 that were Resurfacings by Country in 2004-2006



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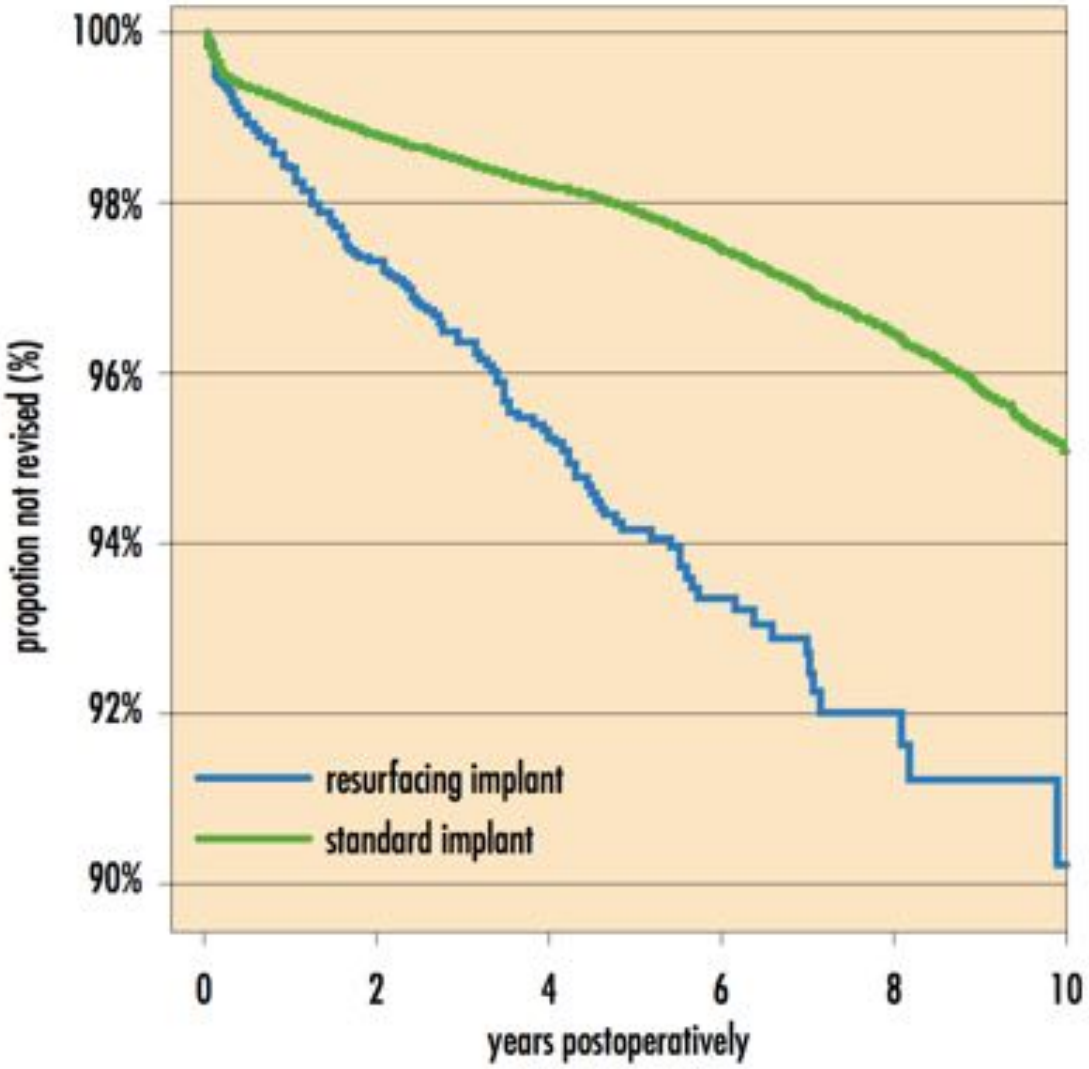
ABSOLUT CHAOS.

ABSOLUT CHAOS.

Resurfacing Has Significantly Worse Outcomes



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New Technology – New Problems

Pseudotumours associated with metal-on-metal hip resurfacings

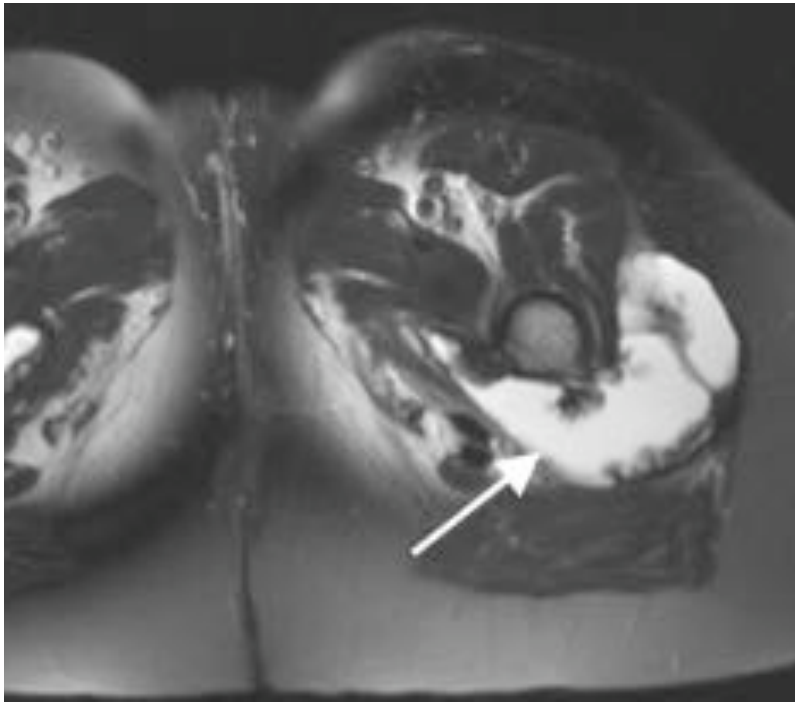
H. Pandit,
S. Glyn-Jones,
P. McLardy-Smith,
R. Gundle,
D. Whitwell,
C. L. M. Gibbons,
S. Ostlere,
N. Athanasou,
H. S. Gill,
D. W. Murray

From The Nuffield Orthopaedic Centre, Oxford, England

We report 17 patients (20 hips) in whom metal-on-metal resurfacing had been performed and who presented with various symptoms and a soft-tissue mass which we termed a pseudotumour. Each patient underwent plain radiography and in some, CT, MRI and ultrasonography were also performed. In addition, histological examination of available samples was undertaken.

All the patients were women and their presentation was variable. The most common symptom was discomfort in the region of the hip. Other symptoms included spontaneous dislocation, nerve palsy, a noticeable mass or a rash. The common histological features were extensive necrosis and lymphocytic infiltration. To date, 13 of the 20 hips have required revision to a conventional hip replacement. Two are awaiting revision.

We estimate that approximately 1% of patients who have a metal-on-metal resurfacing develop a pseudotumour within five years. The cause is unknown and is probably multifactorial. There may be a toxic reaction to an excess of particulate metal wear debris or a hypersensitivity reaction to a normal amount of metal debris. We are concerned that with time the incidence of these pseudotumours may increase. Further investigation is required to define their cause.



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Johnson & Johnson Said to Agree to $4 Billion Settlement Over Hip Implants

Andrew Testa for The New York Times

A faulty Articular Surface Replacement, or A.S.R., removed from a patient in 2010.

What Is the Benefit of Introducing New Hip and Knee Prostheses?

Rajan Anand, MBBS, Stephen E. Graves, MBBS, DPhil, FAOrthA, Richard N. de Steiger, MBBS, Dip Biomech, FRACS(Orth), David C. Davidson, MBBS, FRCSEd, FAOrthA, Philip Ryan, MBBS, BSc, FAFPHM, Lisa N. Miller, BSc Hons (Math), and Kara Cashman, BSC Hons (O&G), Grad Dip Math Sc

Investigation performed at the Australian Orthopaedic Association National Joint Replacement Registry, Adelaide, Australia

- Jan 2003 – Dec 2007
- **266 new hip and knee implants introduced**
- Only ¼ used in more than 100 cases

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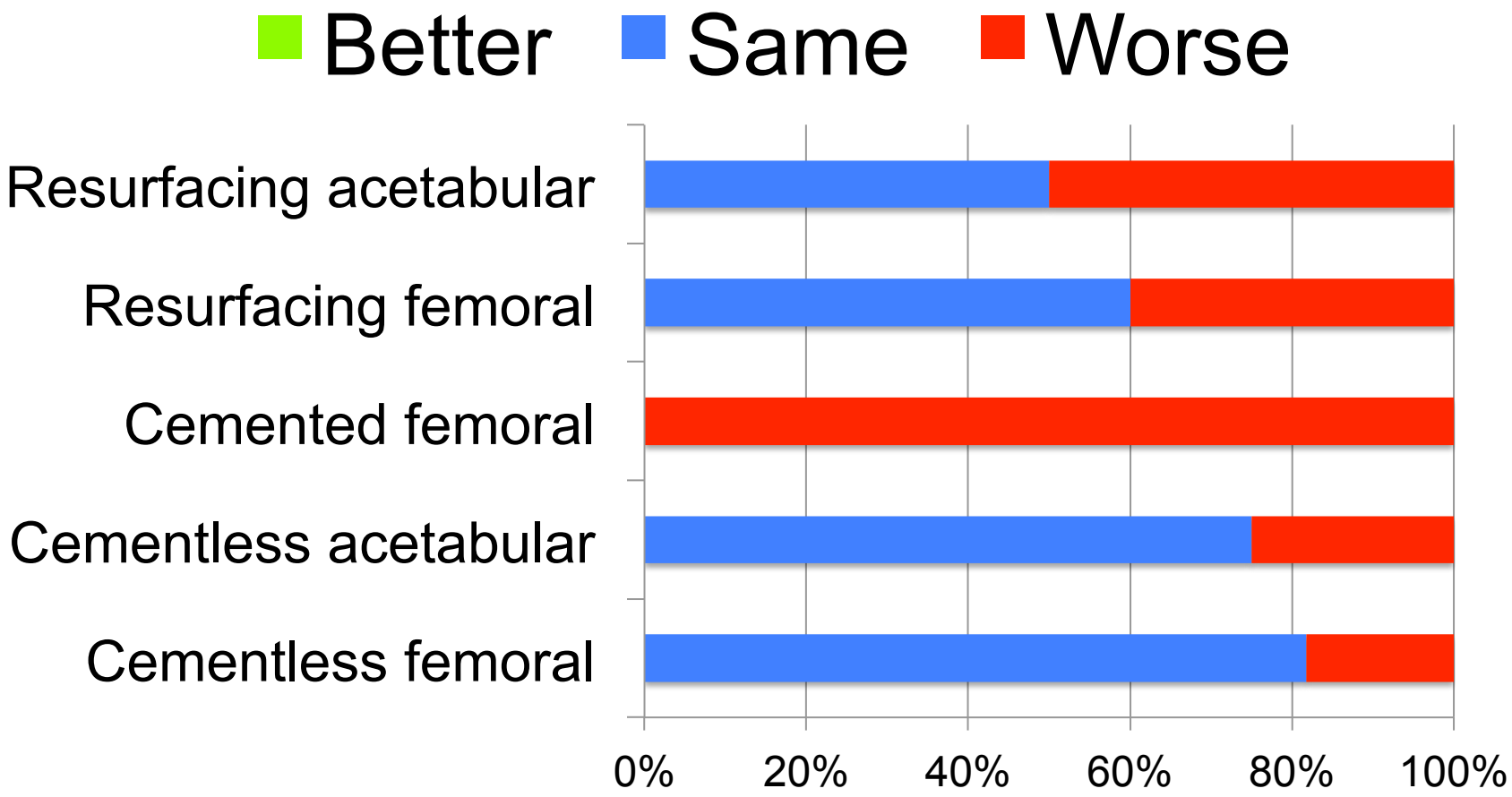
Outcome of New Components Compared to 3 Best Performing Prostheses with > 5 Year data (Australia)



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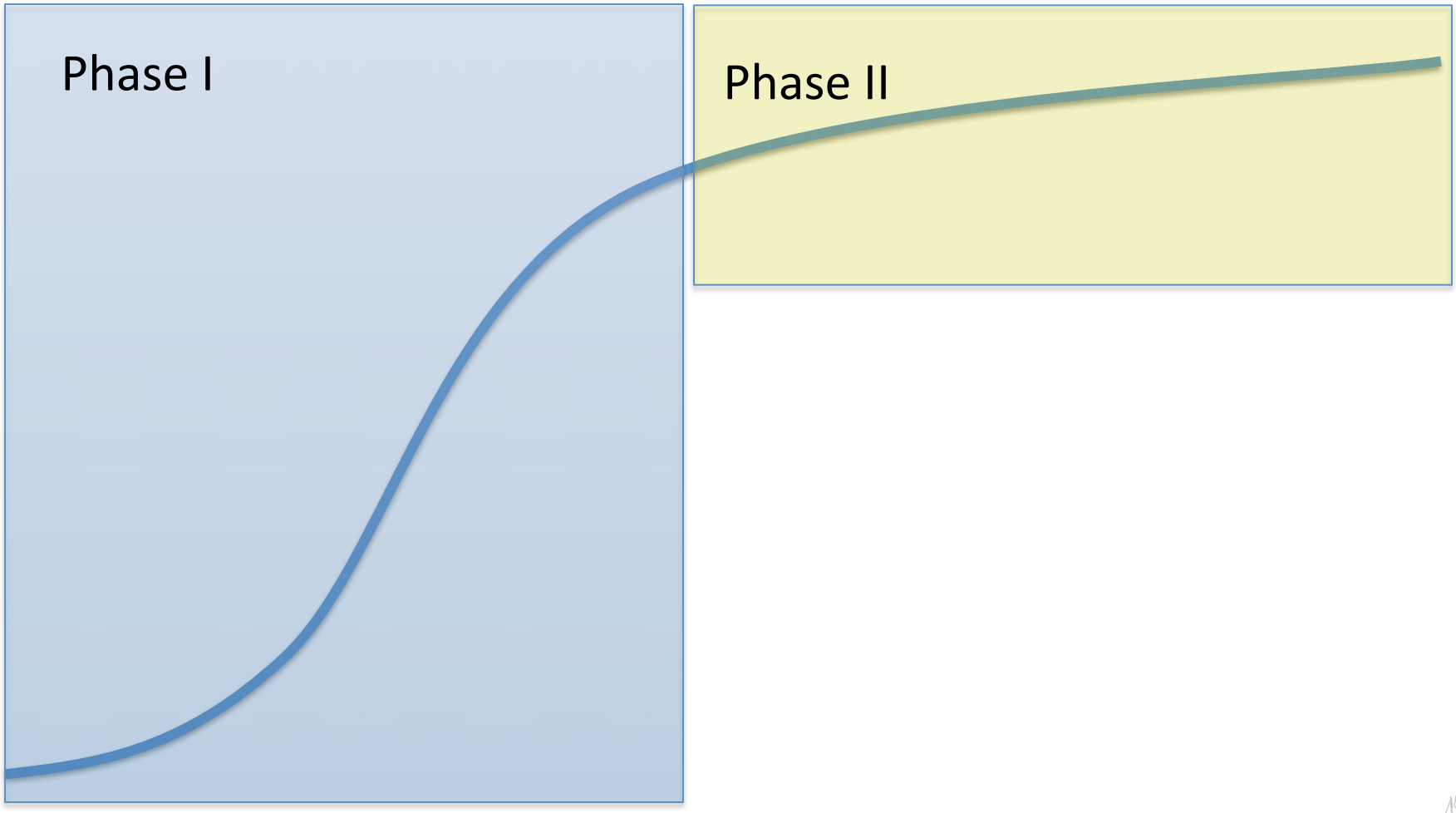
Asymptote to Utopia



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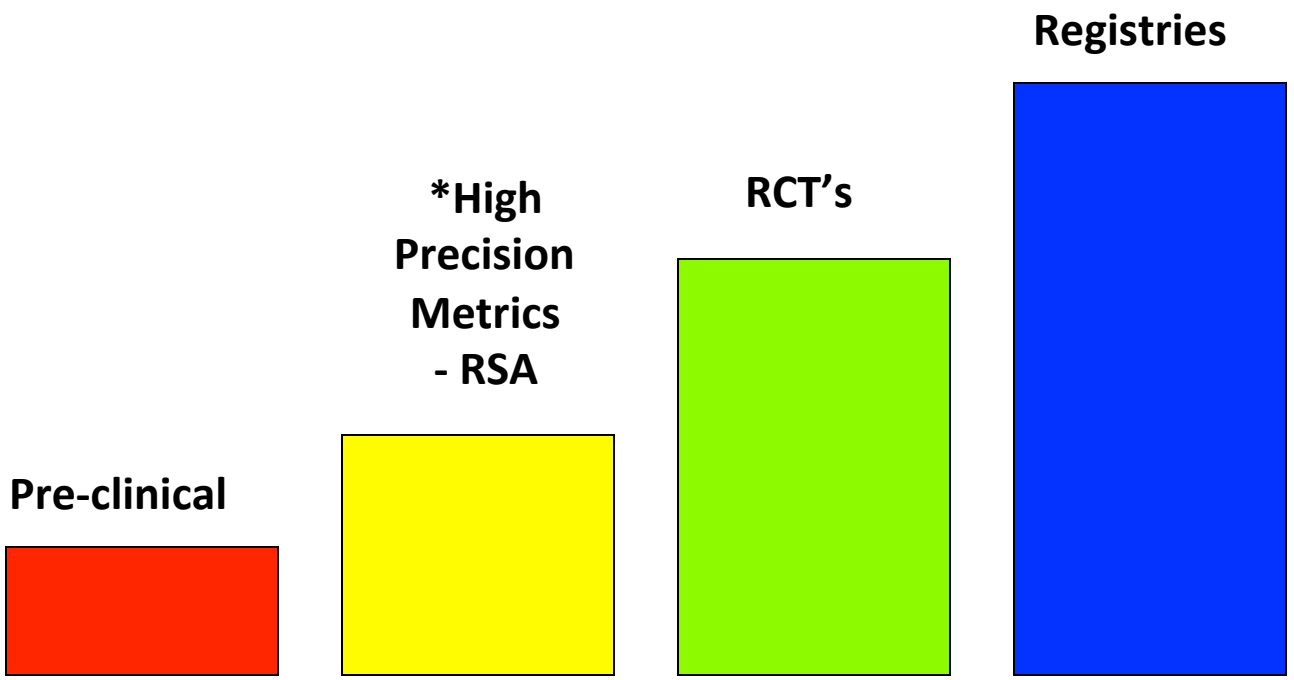
“Phased Innovation”



The Journal of Arthroplasty Vol. 26 No. 6 2011

The Stepwise Introduction of Innovation into Orthopedic Surgery

The Next Level of Dilemmas

Henrik Malchau, MD, PhD, Charles R. Bragdon, PhD, and Orhun K. Muratoglu, PhD

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Atlantic Innovation Fund Award
$5 Million

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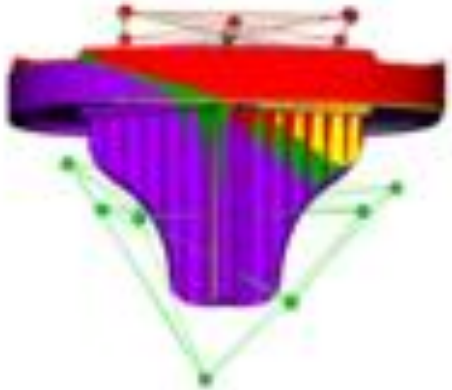
Halifax Biomedical Inc.

Patient with Post Op joint pain?



The Halifax System can provide measurements as accurate as 50 microns to assist in the diagnosis of aseptic loosening

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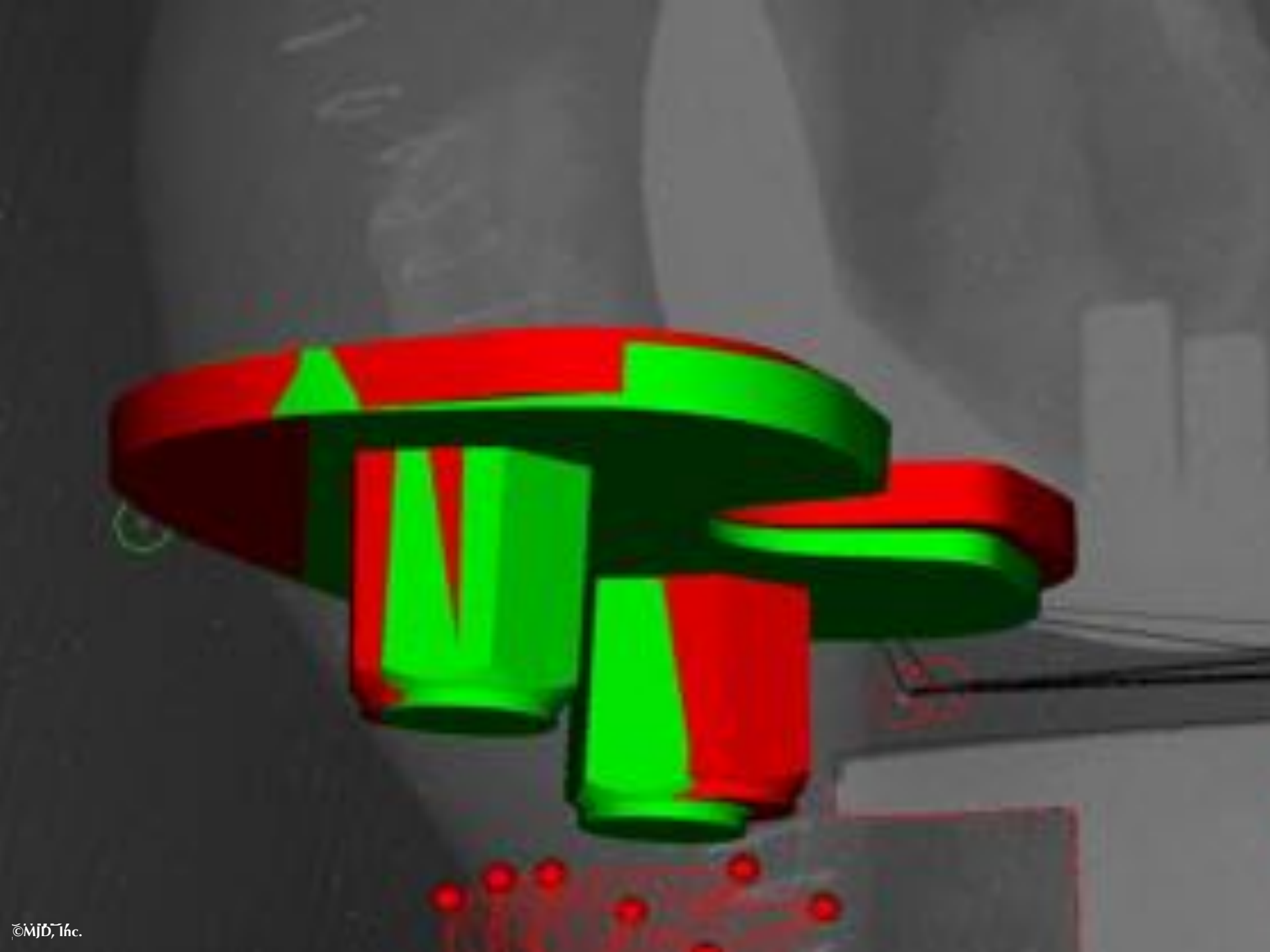
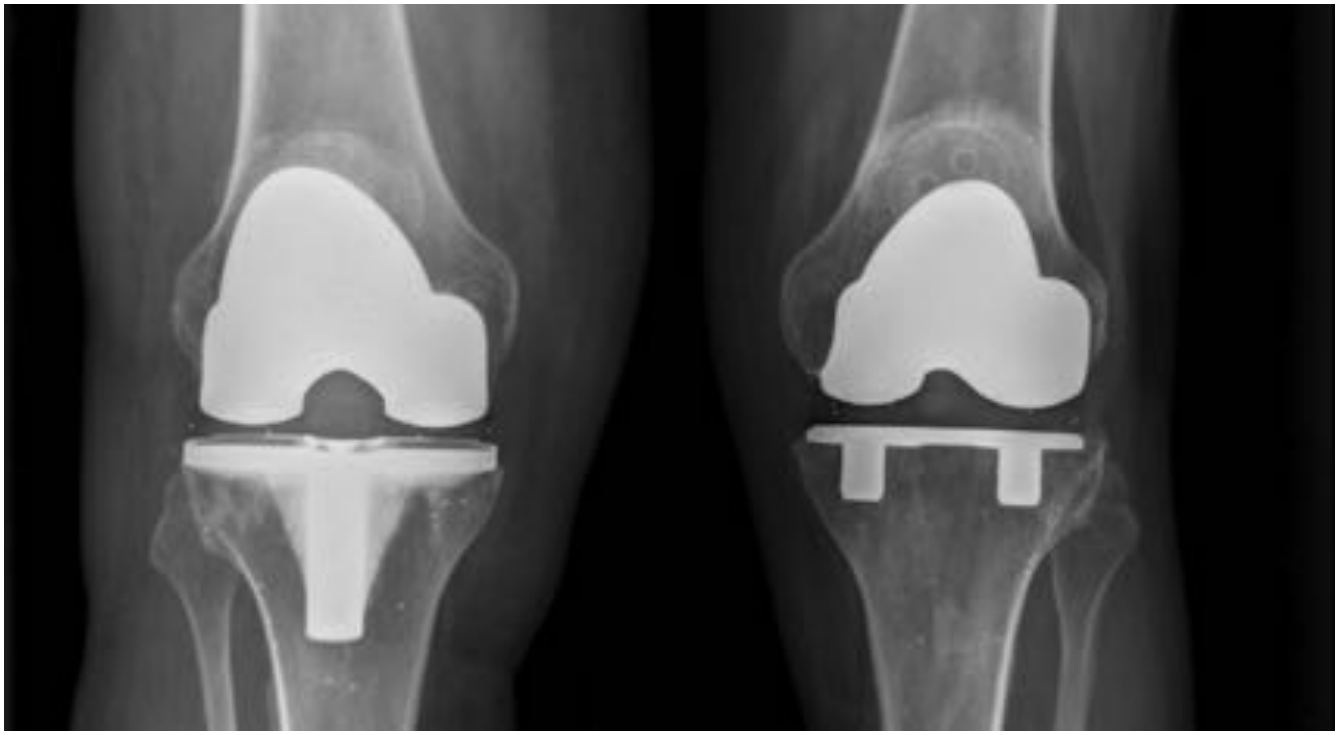


Fixation of a Trabecular Metal Knee Arthroplasty Component

A Prospective Randomized Study

By M.J. Dunbar, MD, FRCSC, PhD, D.A.J. Wilson, MASc, BEng, A.W. Hennigar, BSc, J.D. Amirault, MD, FRCSC, M. Gross, MBBS, FRCSC(LOND), and G.P. Reardon, MD, FRCSC

Investigation performed at the QEII Health Sciences Centre, Halifax, Nova Scotia, Canada



Dynamics of Human Motion Lab

IMPACT

Dynamics of human motion Laboratory

Neuromuscular function Laboratory

Dalhousie University

Inspiring Minds

CIHR IRSC

Canadian Institutes of Health Research

Instituts de recherche en santé du Canada

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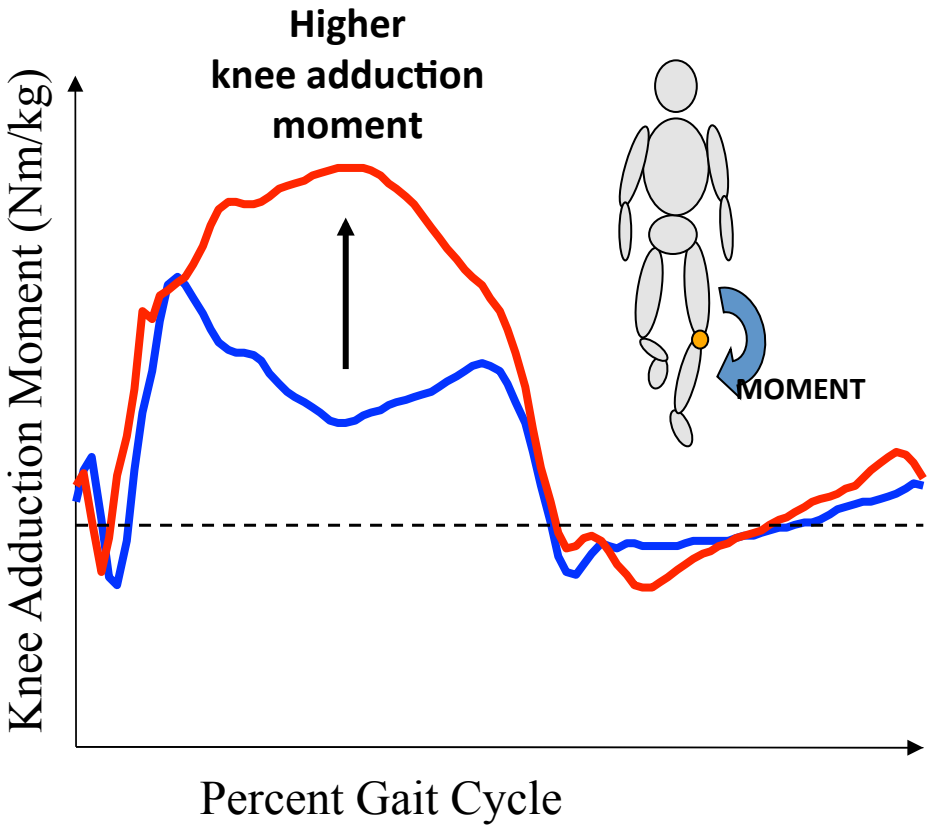
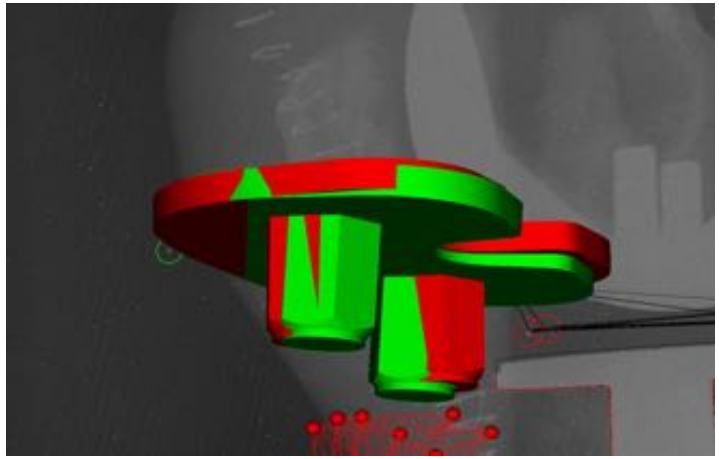
Preoperative gait patterns and BMI are associated with tibial component migration

Janie L Astephen Wilson[1], David A J Wilson[1], Michael J Dunbar[1,2], and Kevin J Deluzio[1,3]





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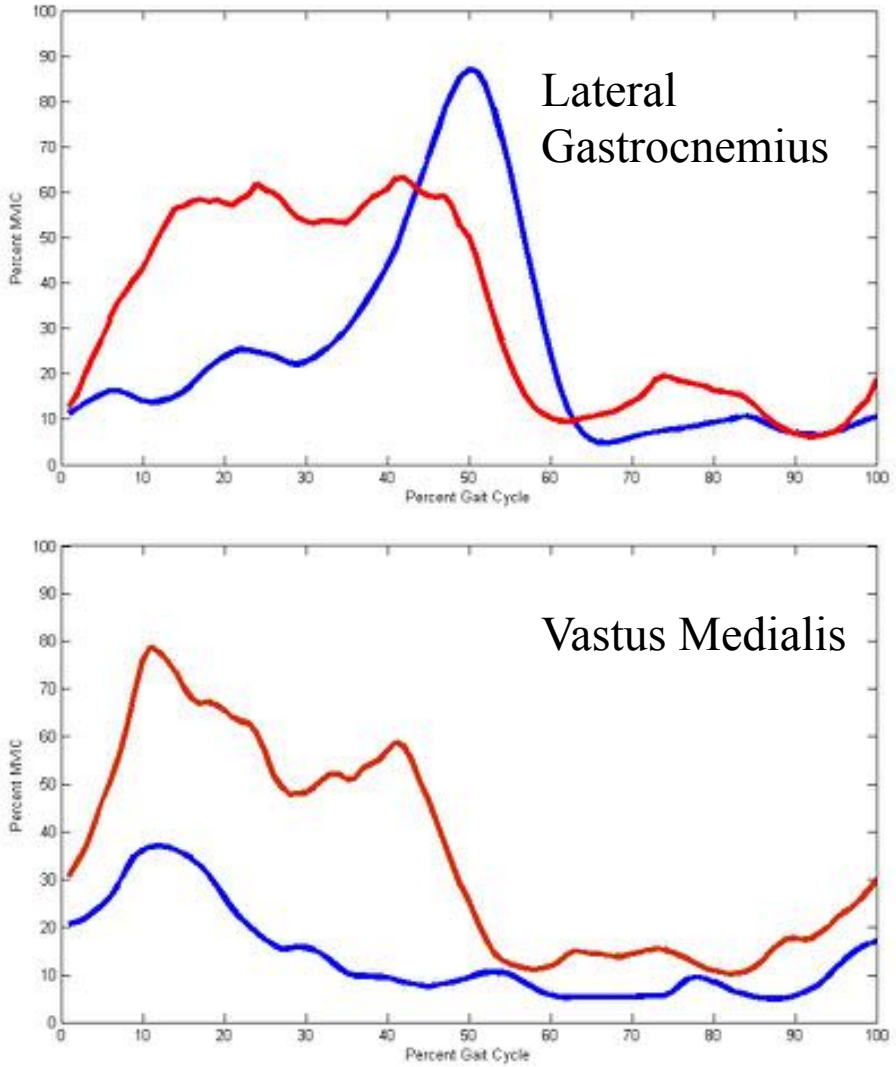
EMG and Migration

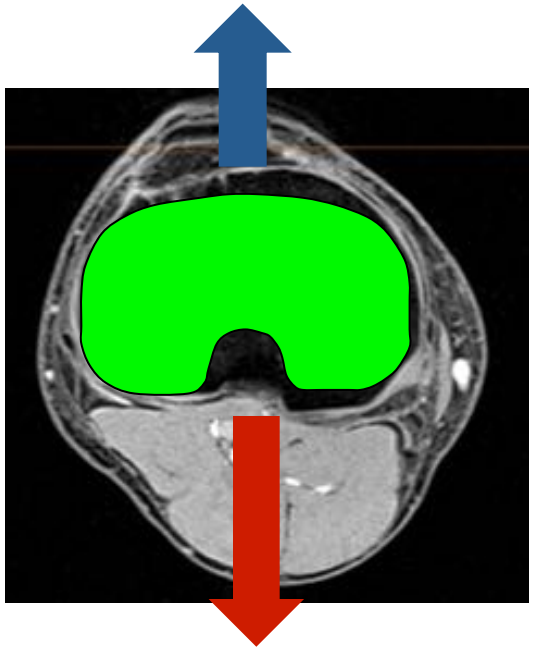


Contents lists available at ScienceDirect
Clinical Biomechanics
journal homepage: www.elsevier.com/locate/clinbiomech

Alterations in neuromuscular patterns between pre and one-year post-total knee arthroplasty

Cheryl L. Hubley-Kozey [a,b,*], Gillian L. Hatfield [b], Janie L. Astephen Wilson [b], Michael J. Dunbar [c,b]

Neutral Migration



Posterior Migration

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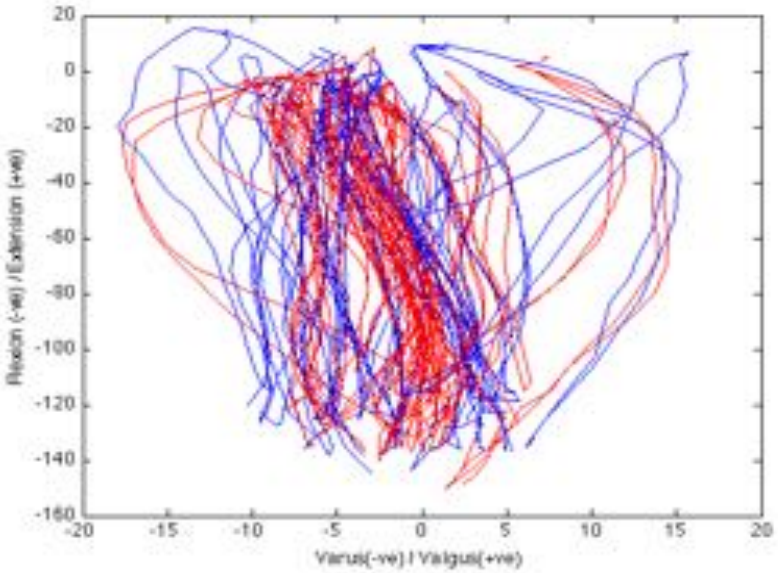
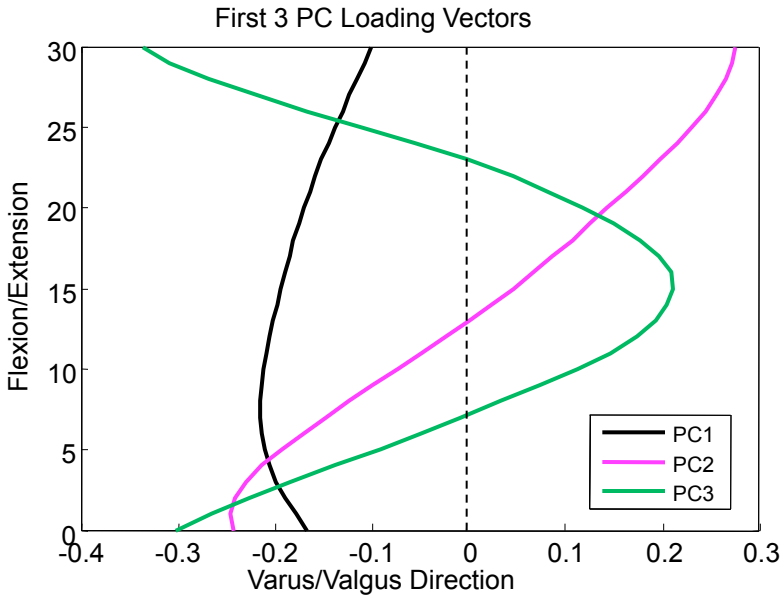
Surgical Navigation

Principal Component Analysis (PCA) of Surgical Navigation Data on 600 cases



PCA



$$Patient_i = a_1 \times PC1 + a_2 \times PC2 + a_3 \times PC3$$

96%

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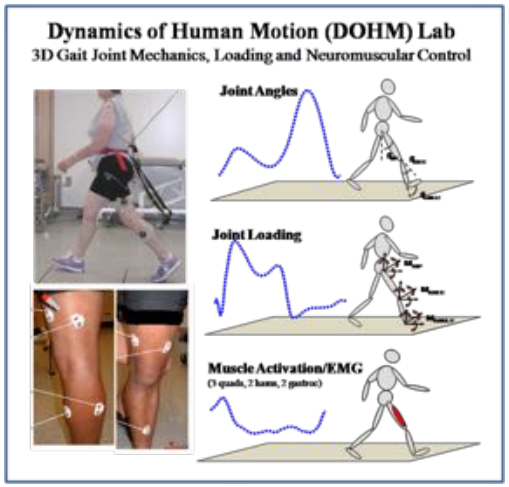
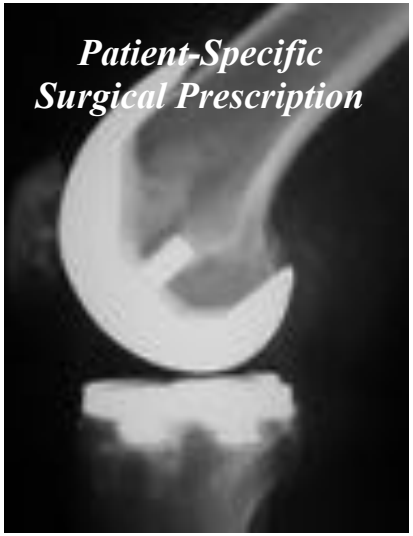
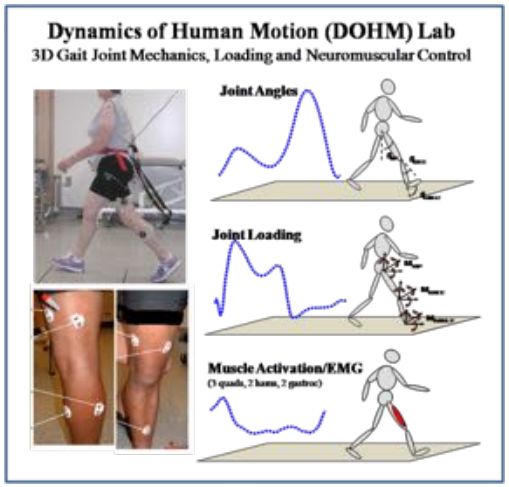
An Objective Framework
TKA Prescription & Assessment

Pre-operative Joint Function
(Dynamic during gait and Passive)





Post-operative Joint Function
(Dynamic during gait and Passive)



Computer Assisted Surgery

Intraoperative Patient Functional & Morphological Characteristics

Post-Operative Outcome

Radiostereometric Analysis (RSA)

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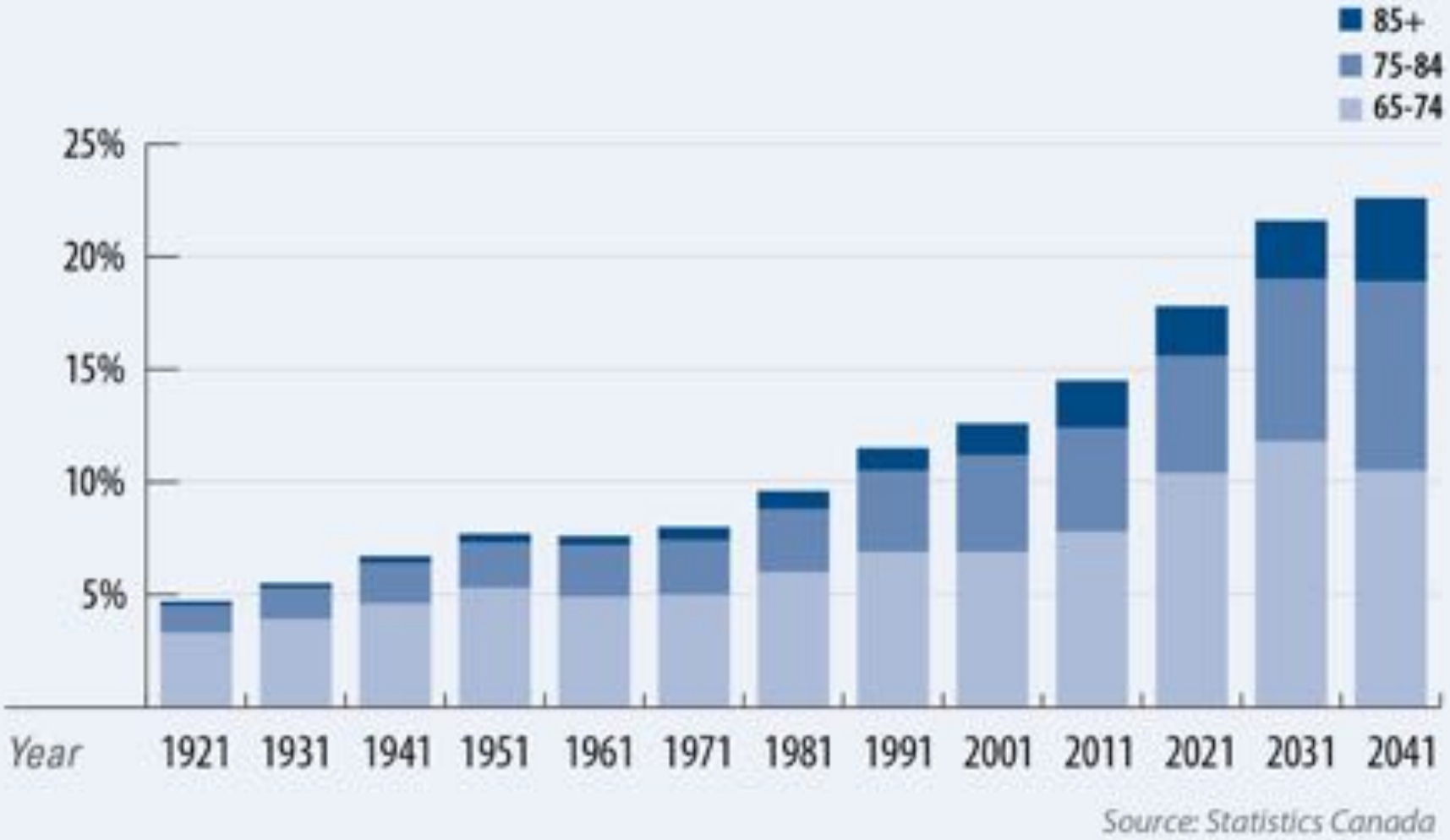

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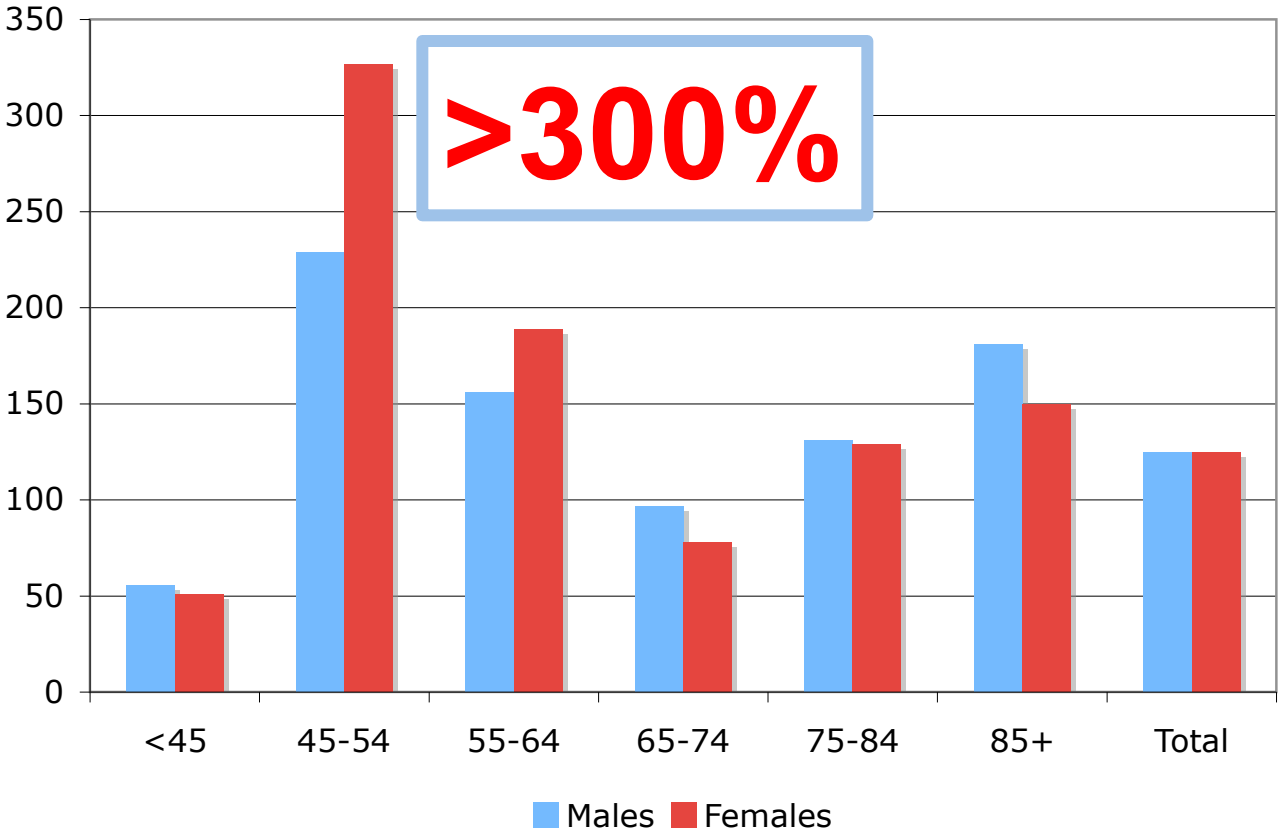
10 Year % Change in Knee Cases in Canada



87%

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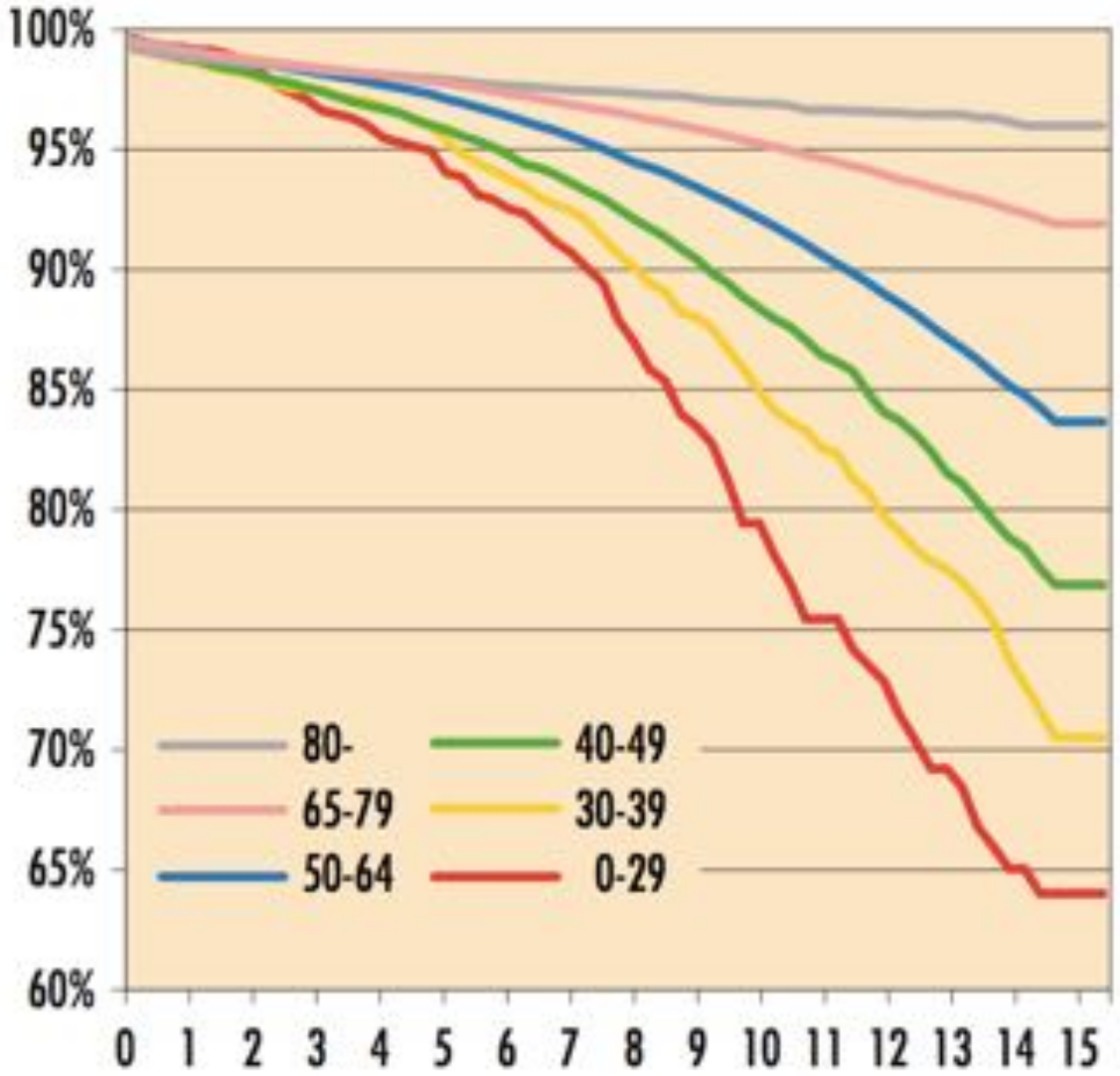
Implant survival based on revision as endpoint for six different age groups (Sweden -THA)



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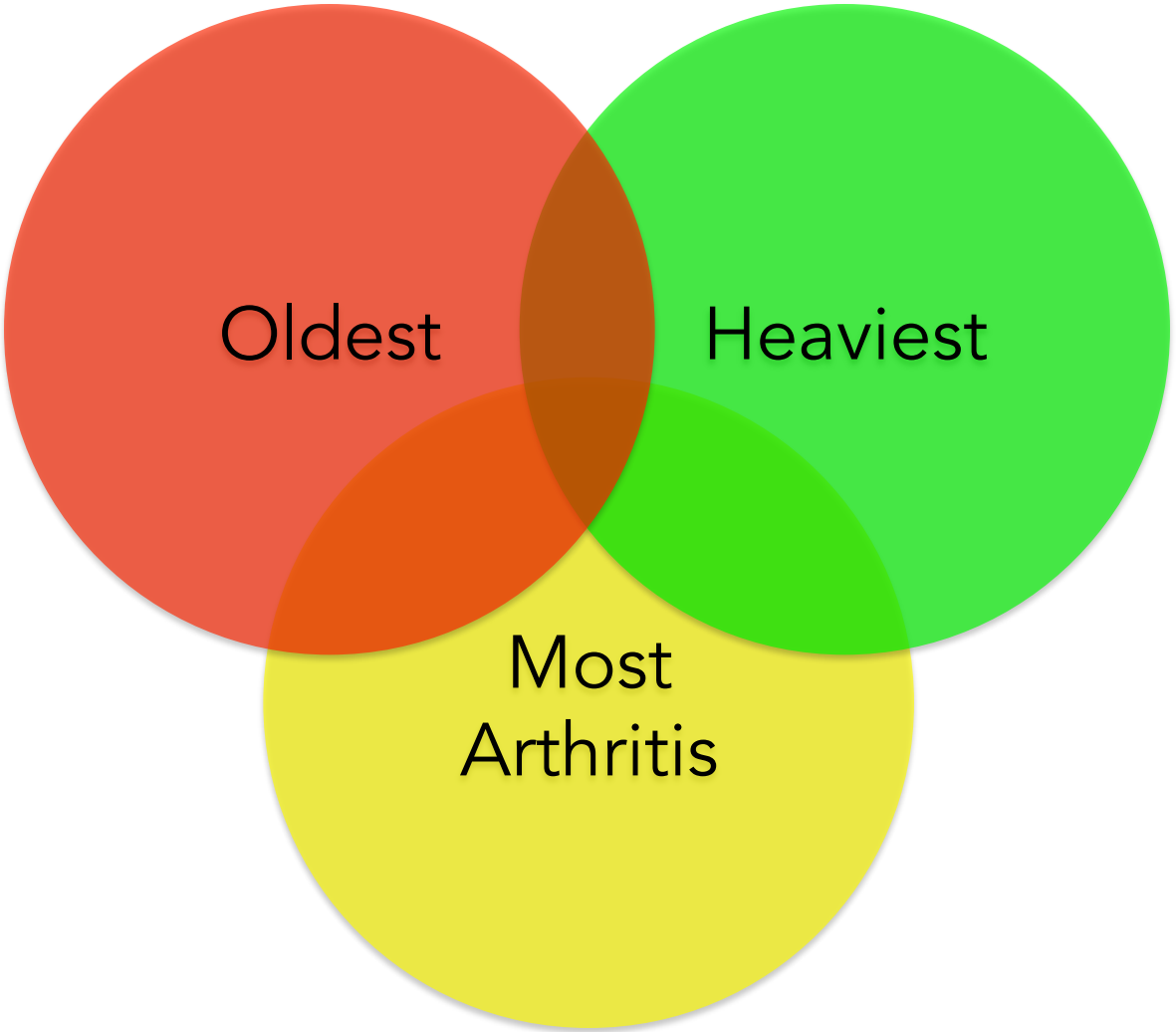
Nova Scotia Compared to Canada



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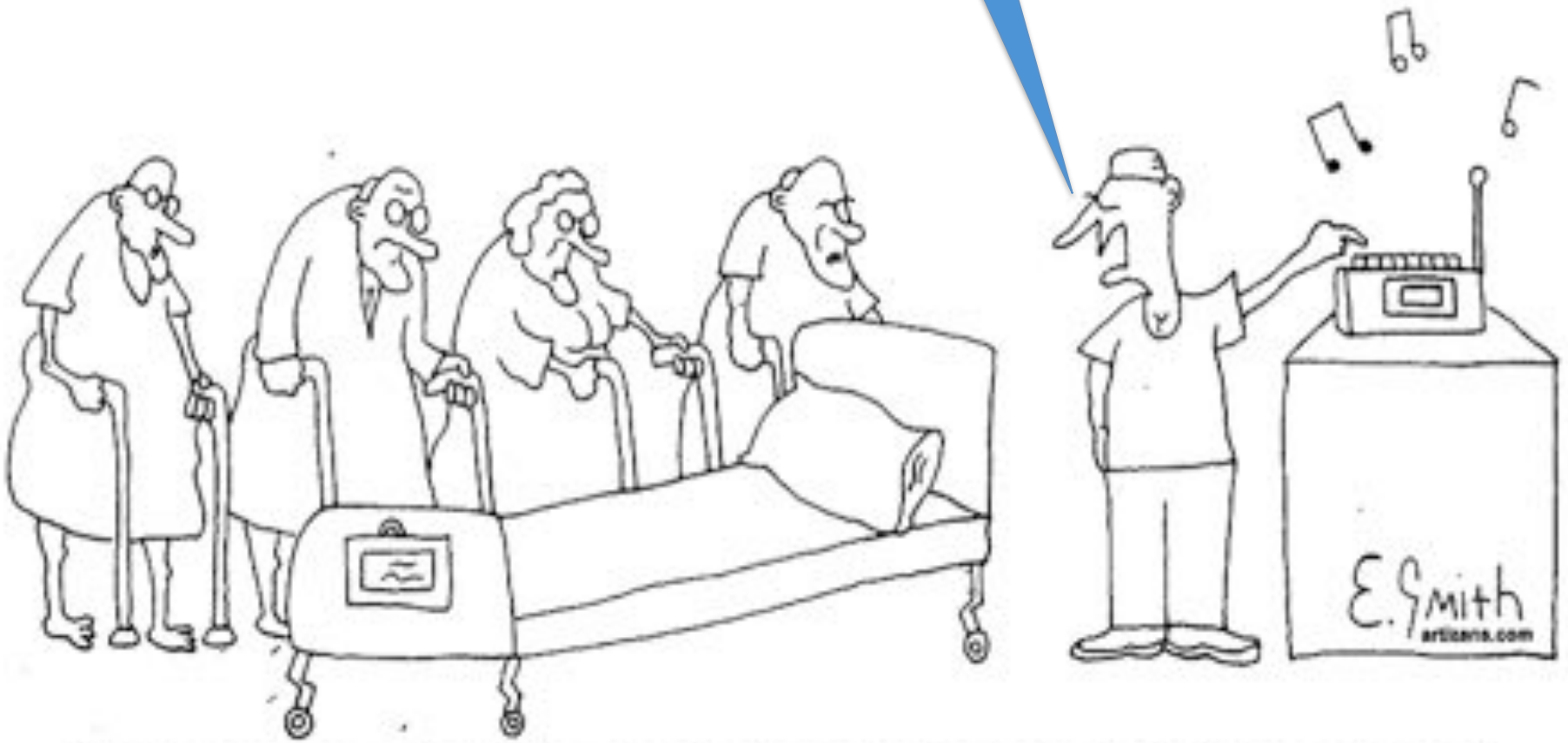
"First one on when the music stops gets todays hip operation"



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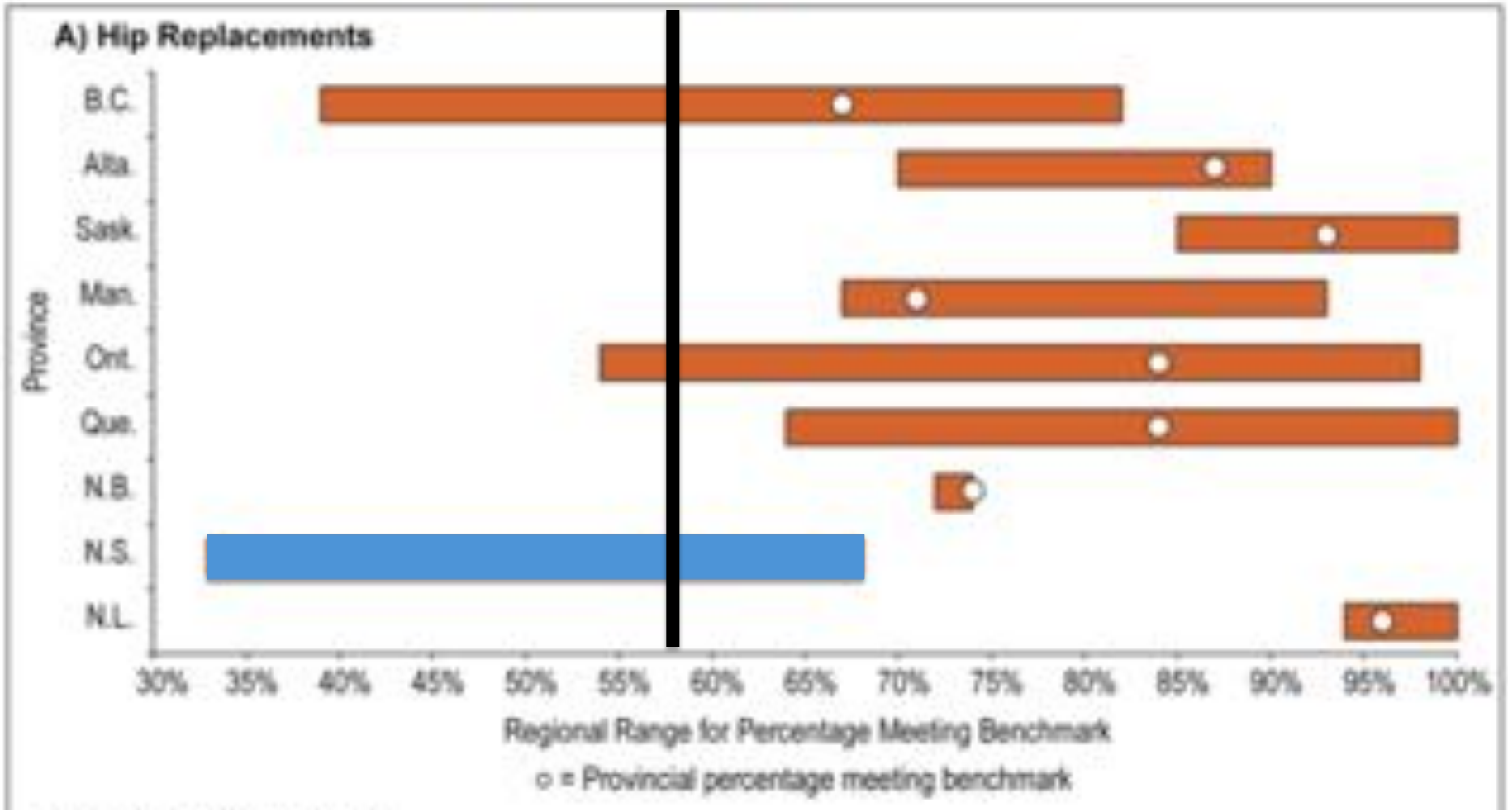
Wait Times for Priority Procedures in Canada, 2015

Report

April 2015

Figure 3: Range in Regional Wait Times for Hip and Knee Replacements by Province, April to September 2014



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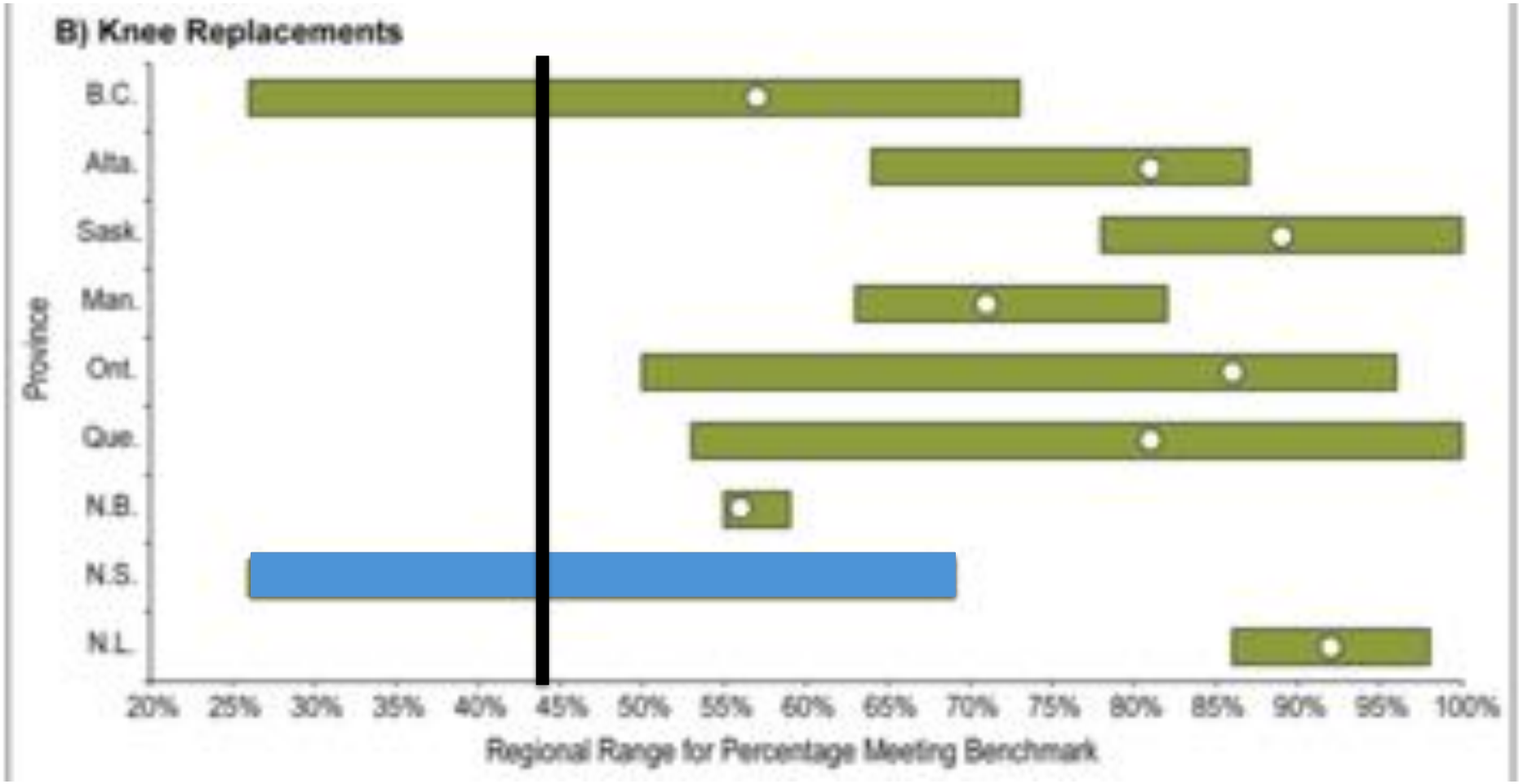

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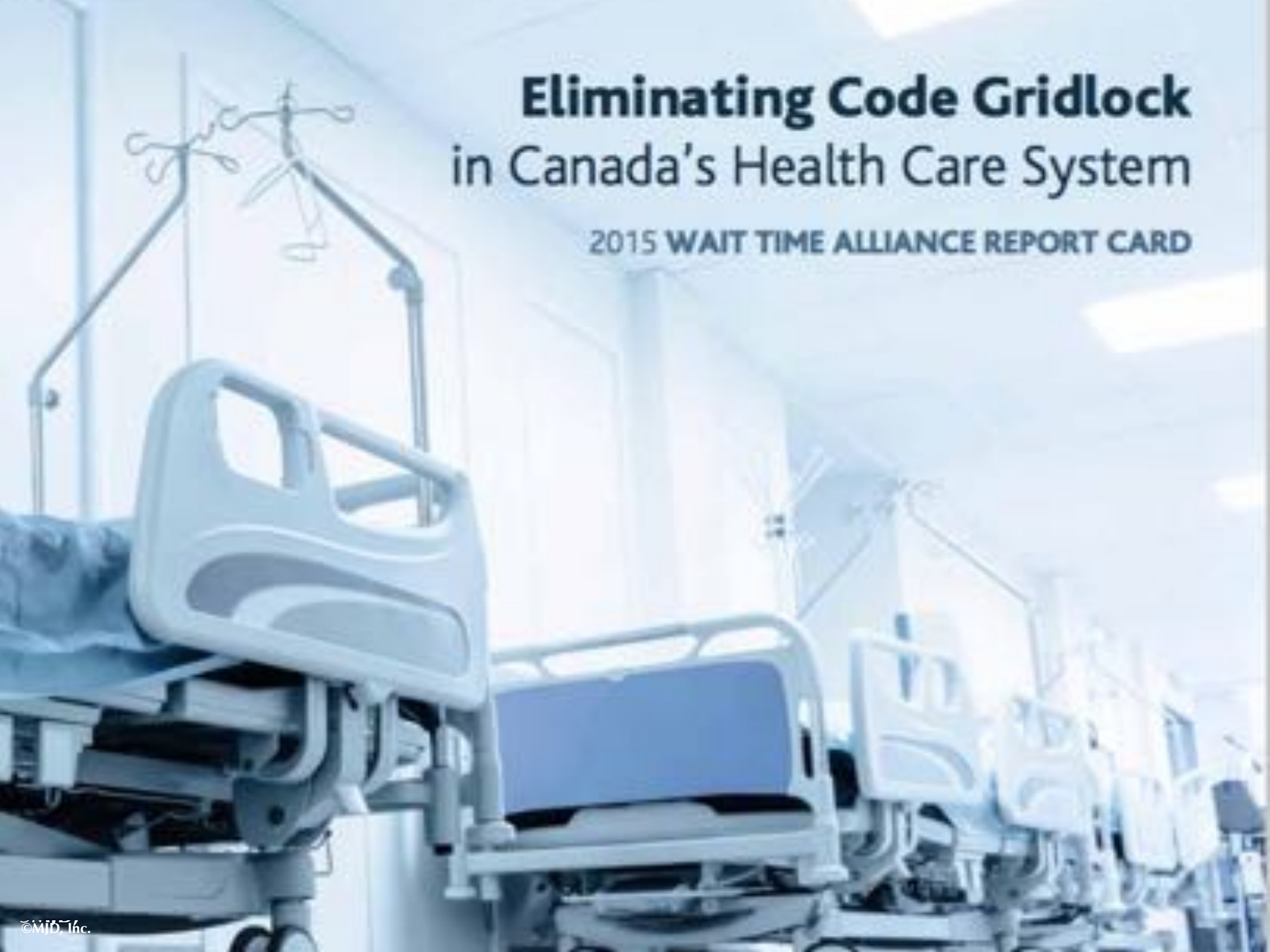

Eliminating Code Gridlock in Canada's Health Care System

2015 WAIT TIME ALLIANCE REPORT CARD

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CIHR Releases Research Results to Inform the Development of Benchmarks for Wait Times

Backgrounder for Wait times for joint replacement surgery

[Press Release 2005-50]

Report 1 / Rapport 1
Due Date / Date Limite: July 22 Juillet 2005

Request for Applications (RFA): Toward Canadian Benchmarks for Health Services Wait Times – Evidence, Application and Research Priorities

FRN # / N° NRF : 75440

NOMINATED PRINCIPAL INVESTIGATOR / CHERCHEUR PRINCIPAL DÉSIGNÉ :	MAILING ADDRESS / ADRESSE POSTALE :
Dr Thomas William Noseworthy, University of Calgary TEL / TÉL. : 403-220-2481 FAX / TÉLÉC. : 403-220-7307	Room G06, Heritage Medical Research Building University of Calgary 3330 Hospital Drive NW Calgary AB T2N 4N1

TITLE OF YOUR RESEARCH GRANT / TITRE DE VOTRE SUBVENTION DE RECHERCHE :

Towards Establishing Evidence-Based Benchmarks for Acceptable Waiting Times for Joint Replacement Surgery

CO-PRINCIPAL INVESTIGATORS, CO-INVESTIGATORS and CO-APPLICANTS:

Co-Principal Investigator
Dr Claudia Sanmartin, University of Calgary and Statistics Canada

Co-Investigators
Dr Eric Bohm, University of Manitoba
Dr Barbara Conner-Spady, University of Calgary
Dr Carolyn DeCoster, University of Calgary
Dr Mike Dunbar, Dalhousie University
Ms Diane Lorenzetti, University of Calgary

New Co-investigator
Dr Lindsay McLaren, University of Calgary

Collaborator
Mr John McGurran, Western Canada Waiting List Project (WCWL)

Capital Health

Dalhousie University

DEPARTMENT OF SURGERY

WAIT LIST MANAGEMENT PROJECT

ORTHOPAEDIC PILOT PROJECT

QUEEN ELIZABETH II HEALTH SCIENCES CENTRE

Michael J. Dunbar, MD, FRCSC, PhD
Director of Orthopaedic Research
Clinical Research Scholar
Dalhousie University

Lynn Molloy
Wait List Project Coordinator CDHA

John T. Blake, PEng, PhD
Associate Professor
Dalhousie University

Allan Hemmgar, BSc
Orthopaedic Research Manager

Jane Storey, BSc Health Ed.
Research Assistant

January 2004

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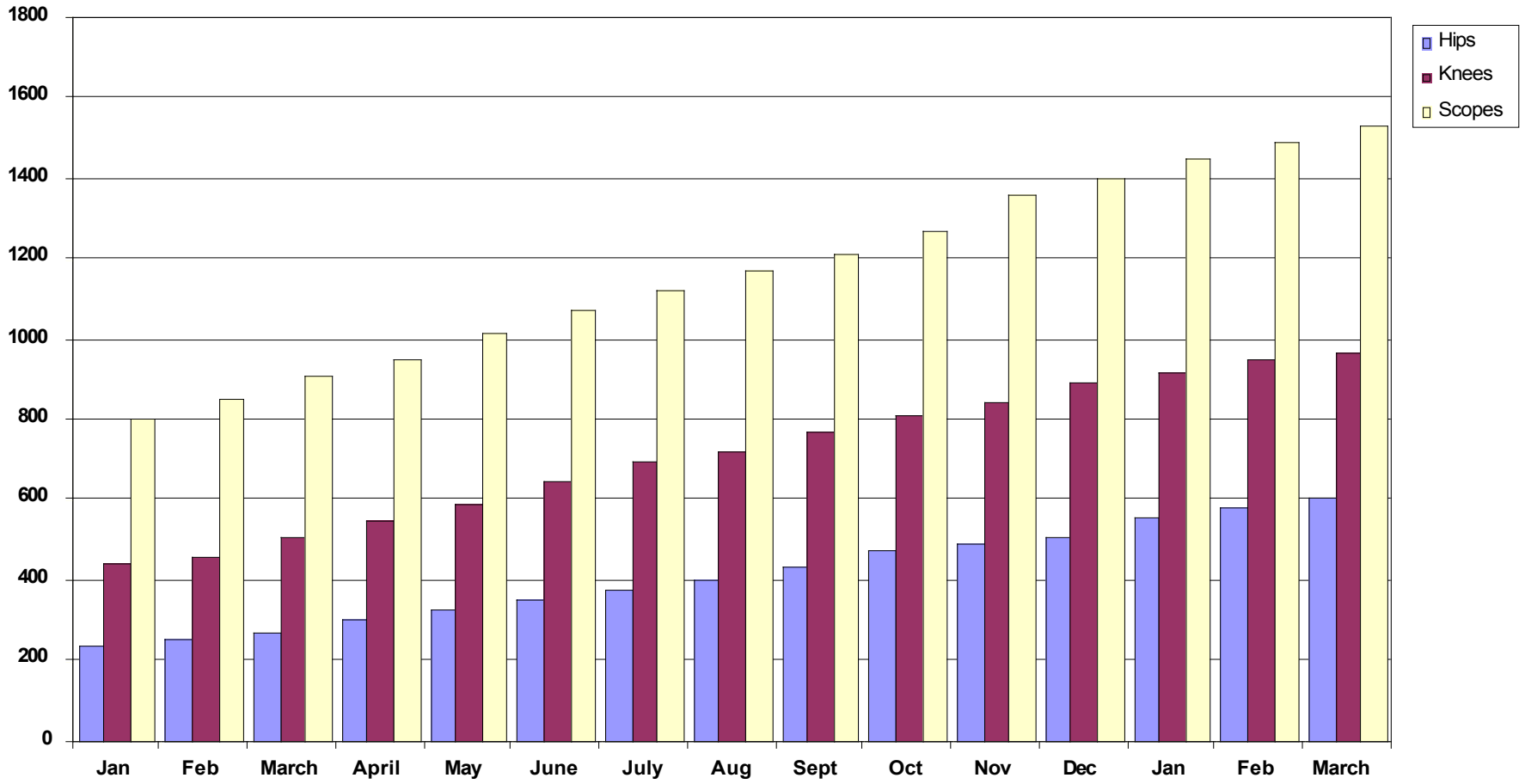
Arthroplasty Patients Waiting for Surgery (QEII)
2003/04



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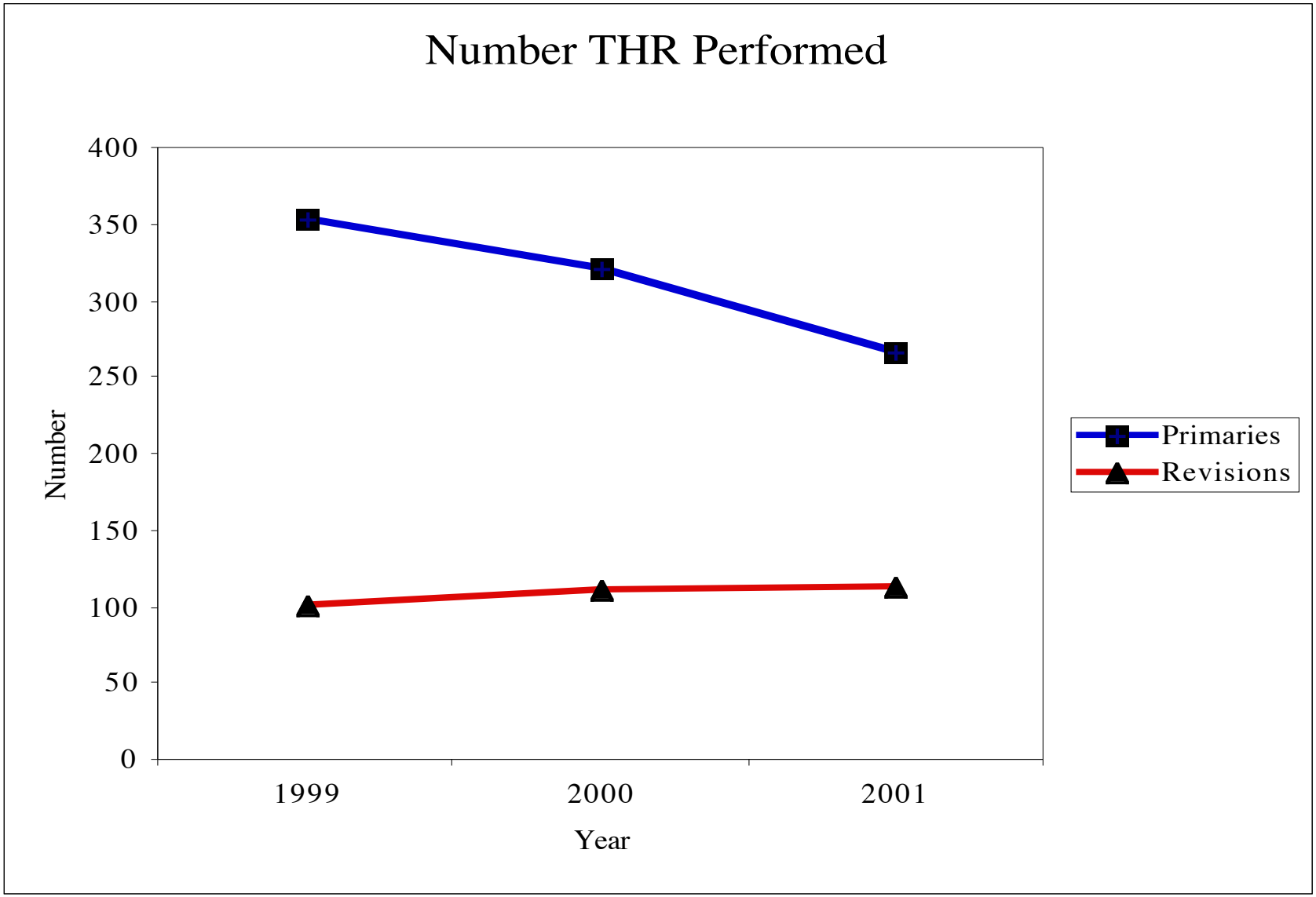

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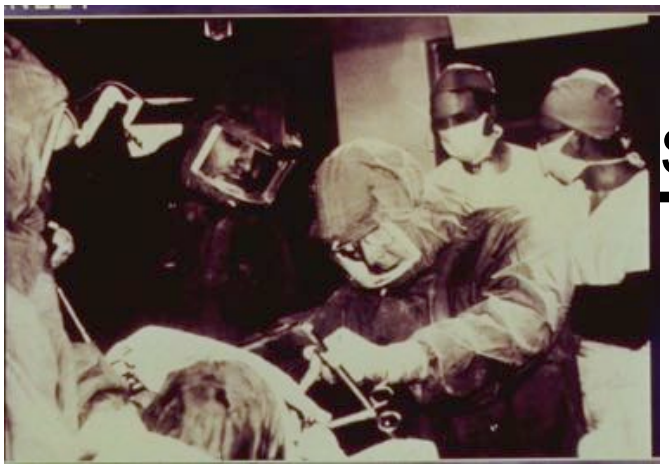
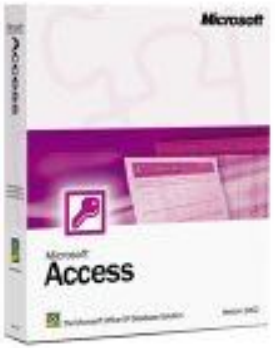
Real Life vs. the Simulation



System Attributes

- **Patient Arrival Rates**
- **Operation Type**
- **Surgery Time**
- **Recovery Time**
- **Doctors' Schedules**
- **Recovery Beds**



System Process

- **Wait List**
- **Patient Flow**
- **Resources Needed**

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Model Development

Verification and Validation

Determine Patient Through Put
Determine Patient Discharge Rate
Determine Patient Time in System
Determine Patient Time in a Queue
Determine Bed Utilization
Determine OR Utilization
Determine Waitlist Growth Rate

Compare and Contrast
to Actual System

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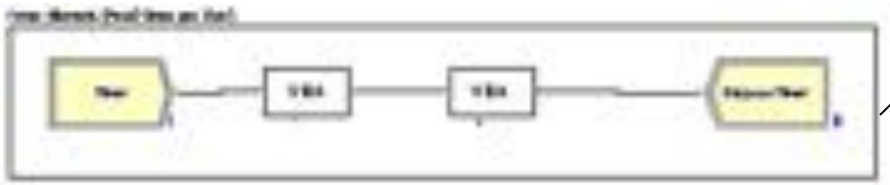
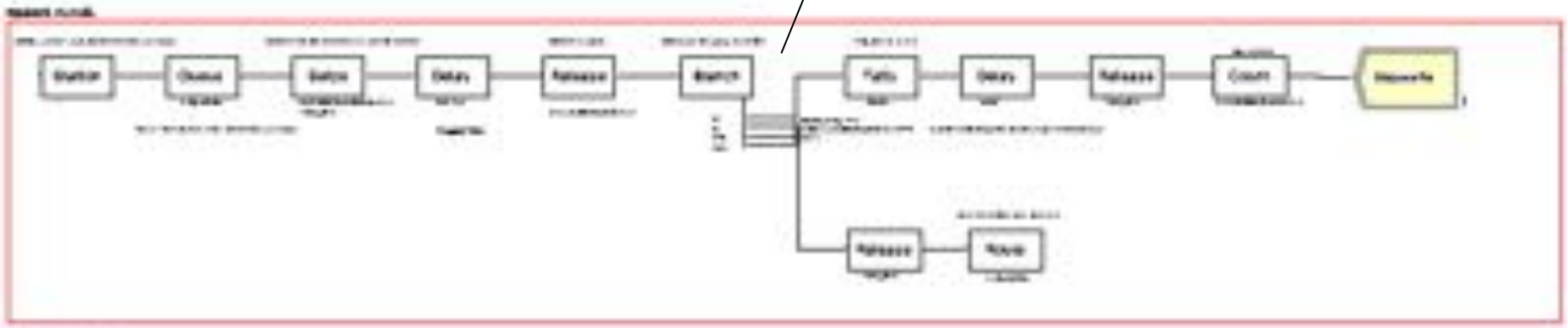
Actual Arena Model

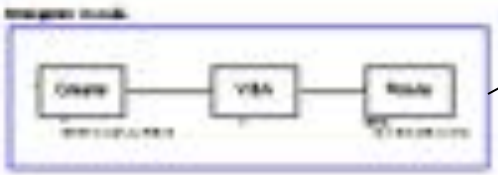


Create Patients and Doctors Schedule

Reduces Doctor's Schedule after Surgery

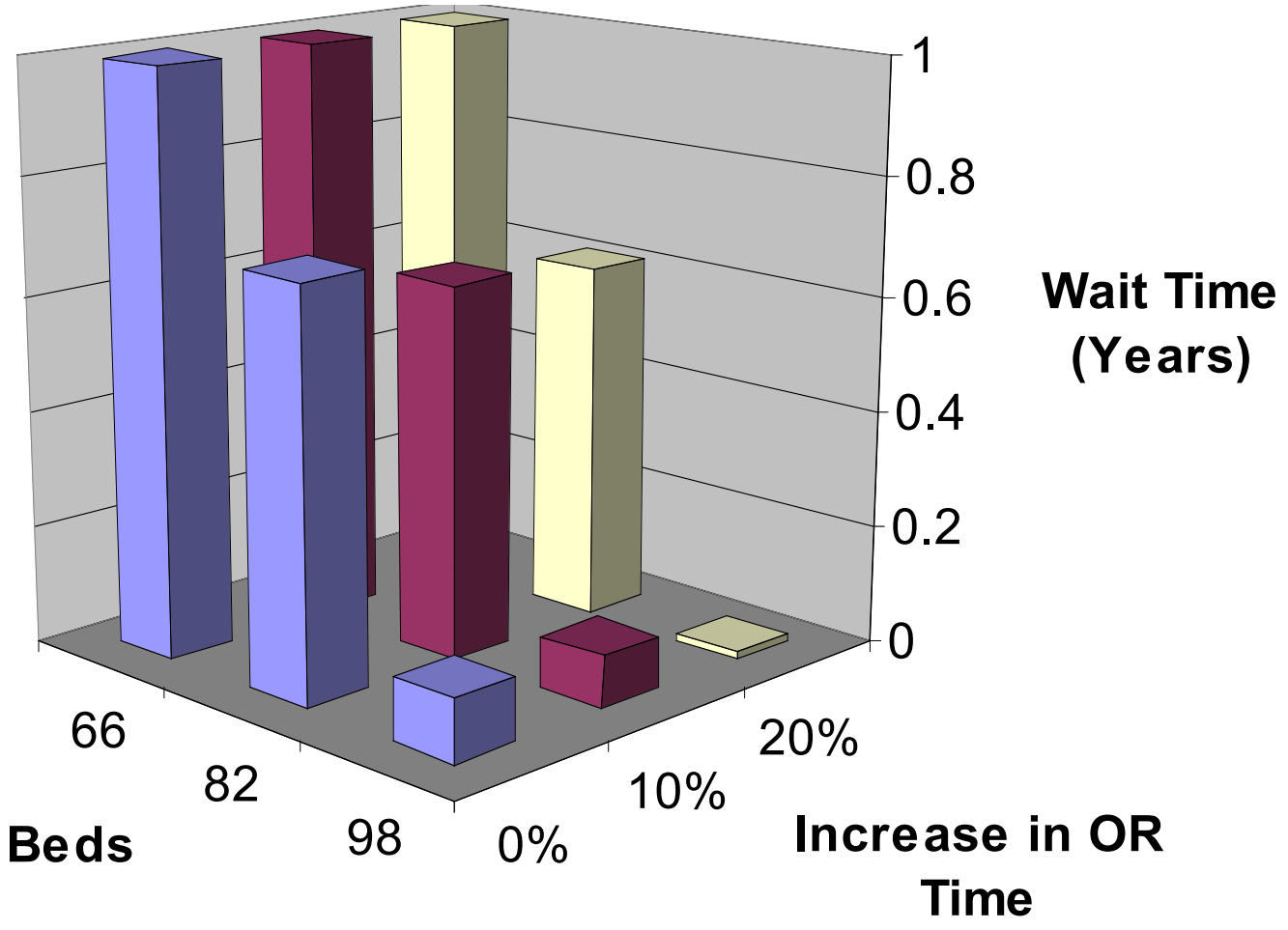


Acts as Hospital. Patients Flow Through

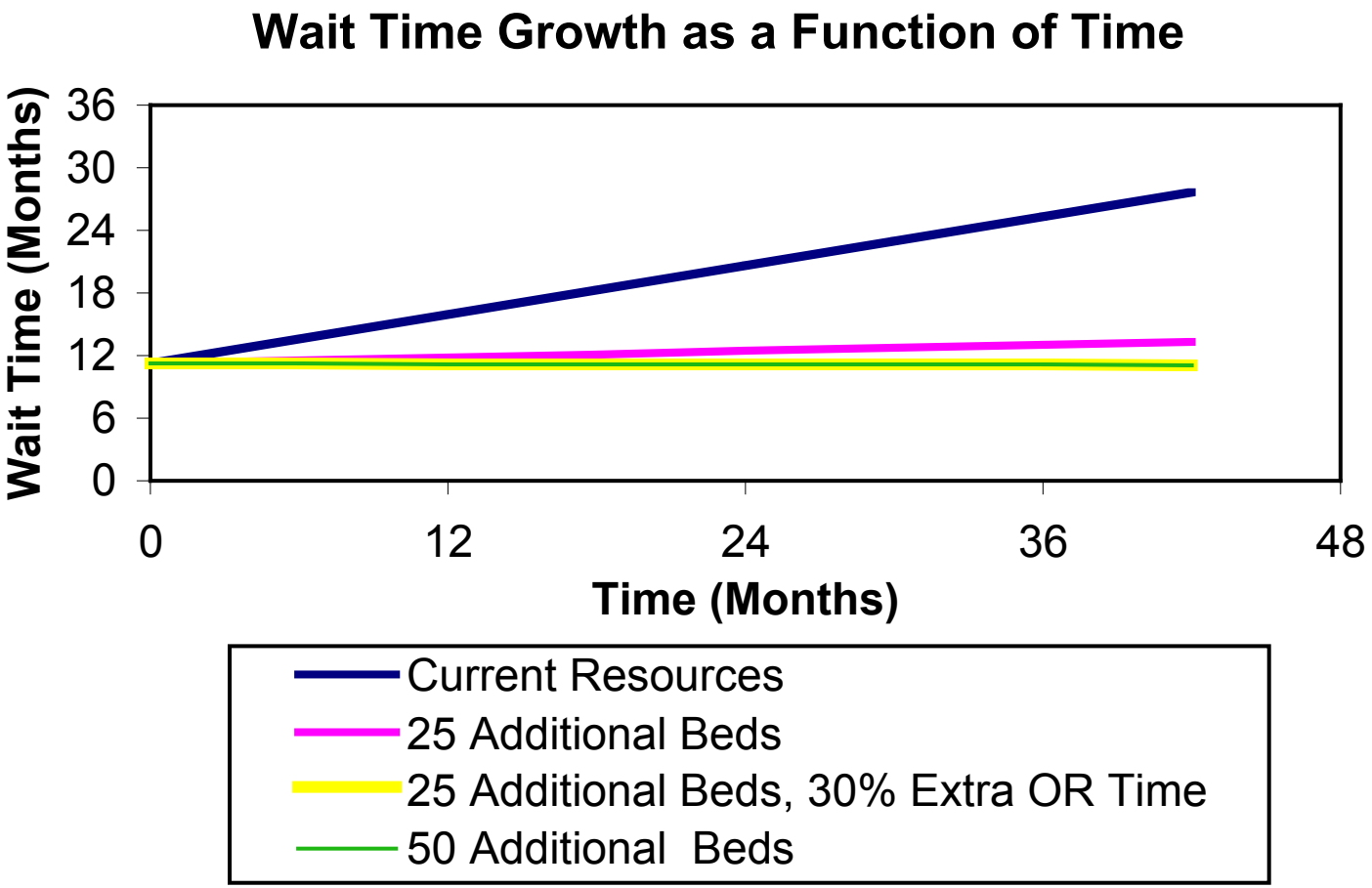


Creates Emergency Patients and Sends them to Hospital

Ortho Wait Times as a Function of Beds and OR Time



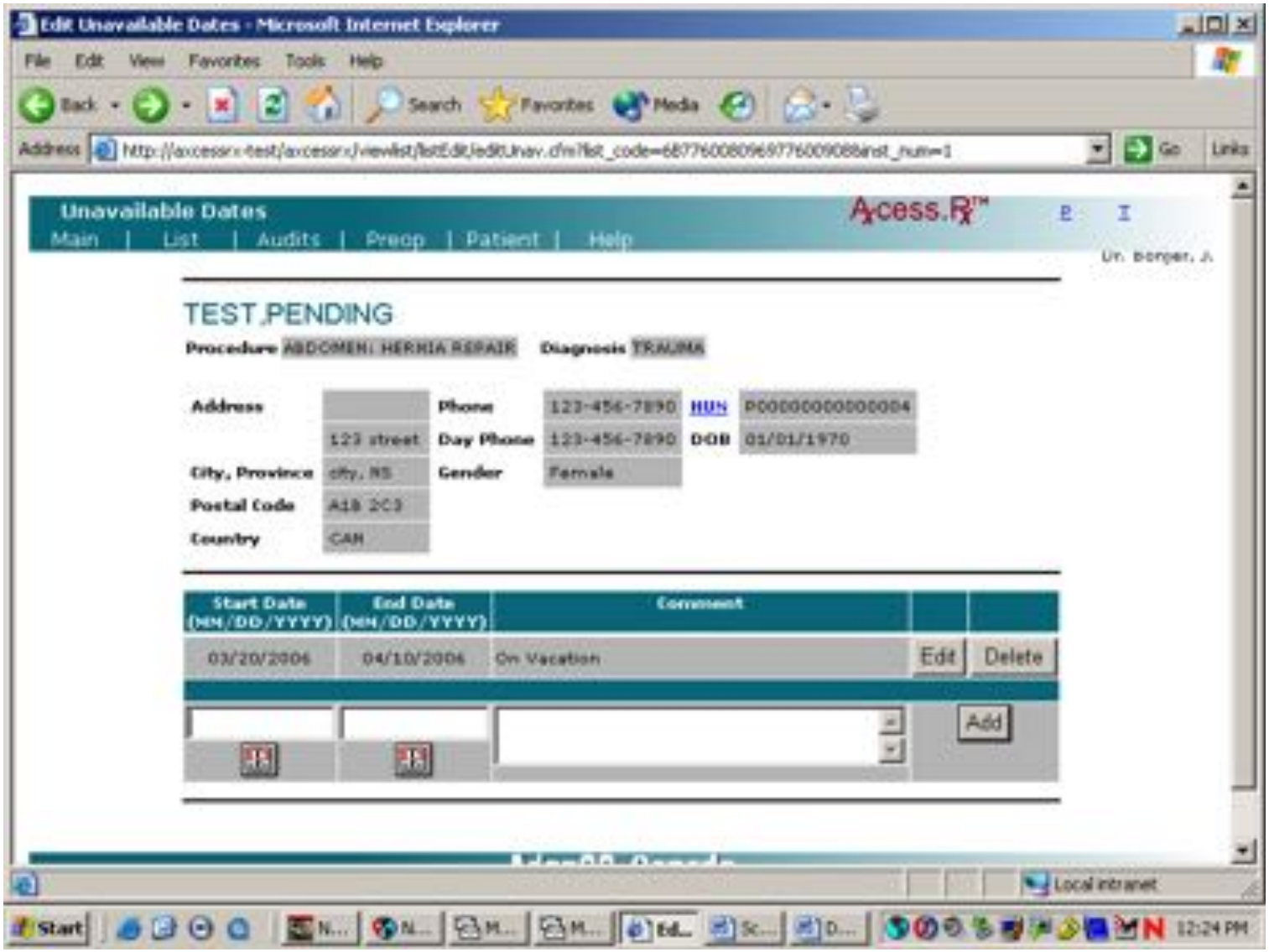
DALHOUSIE Orthopaedics



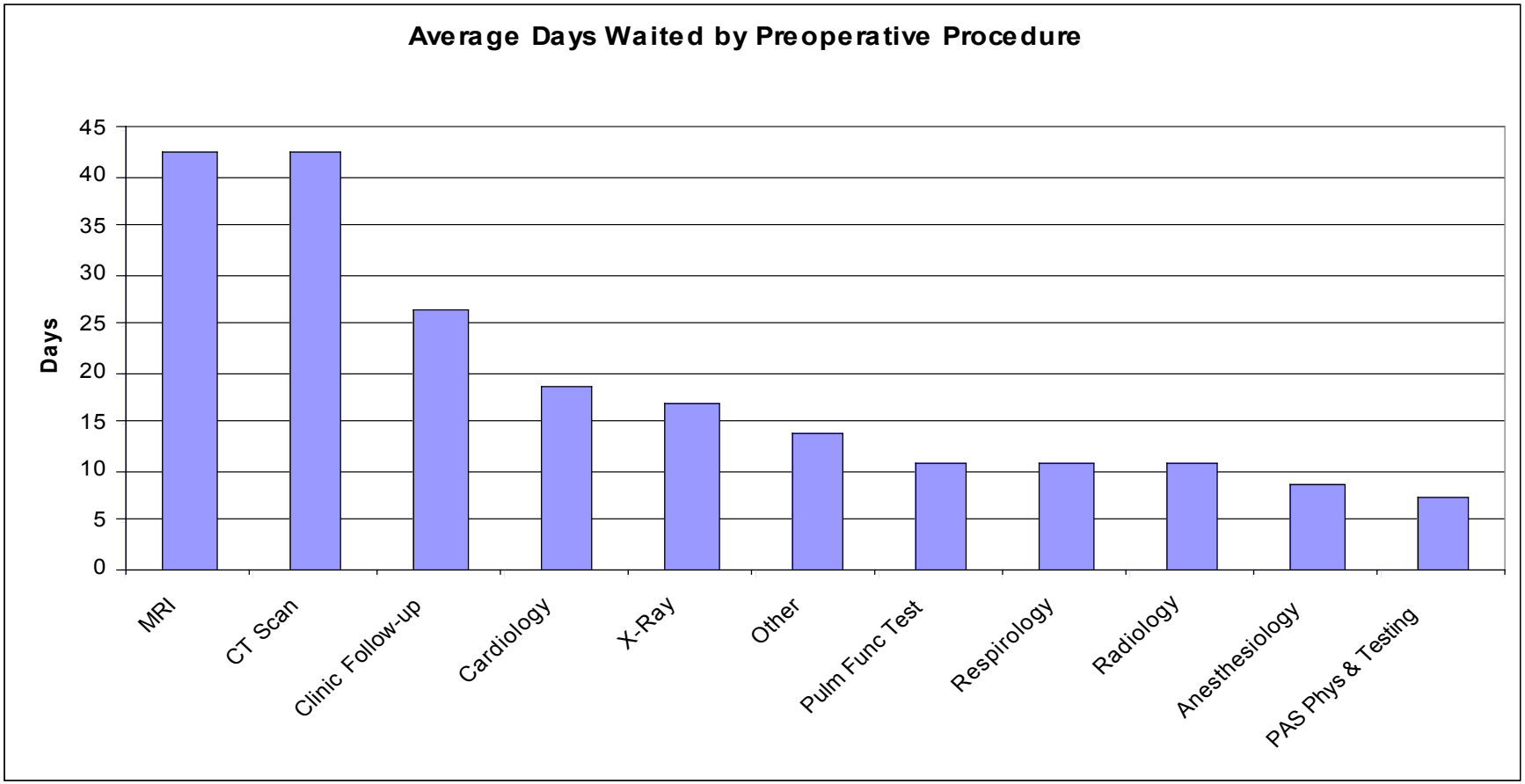
DALHOUSIE
Orthopaedics

Nova Scotia Department of Health Announcement

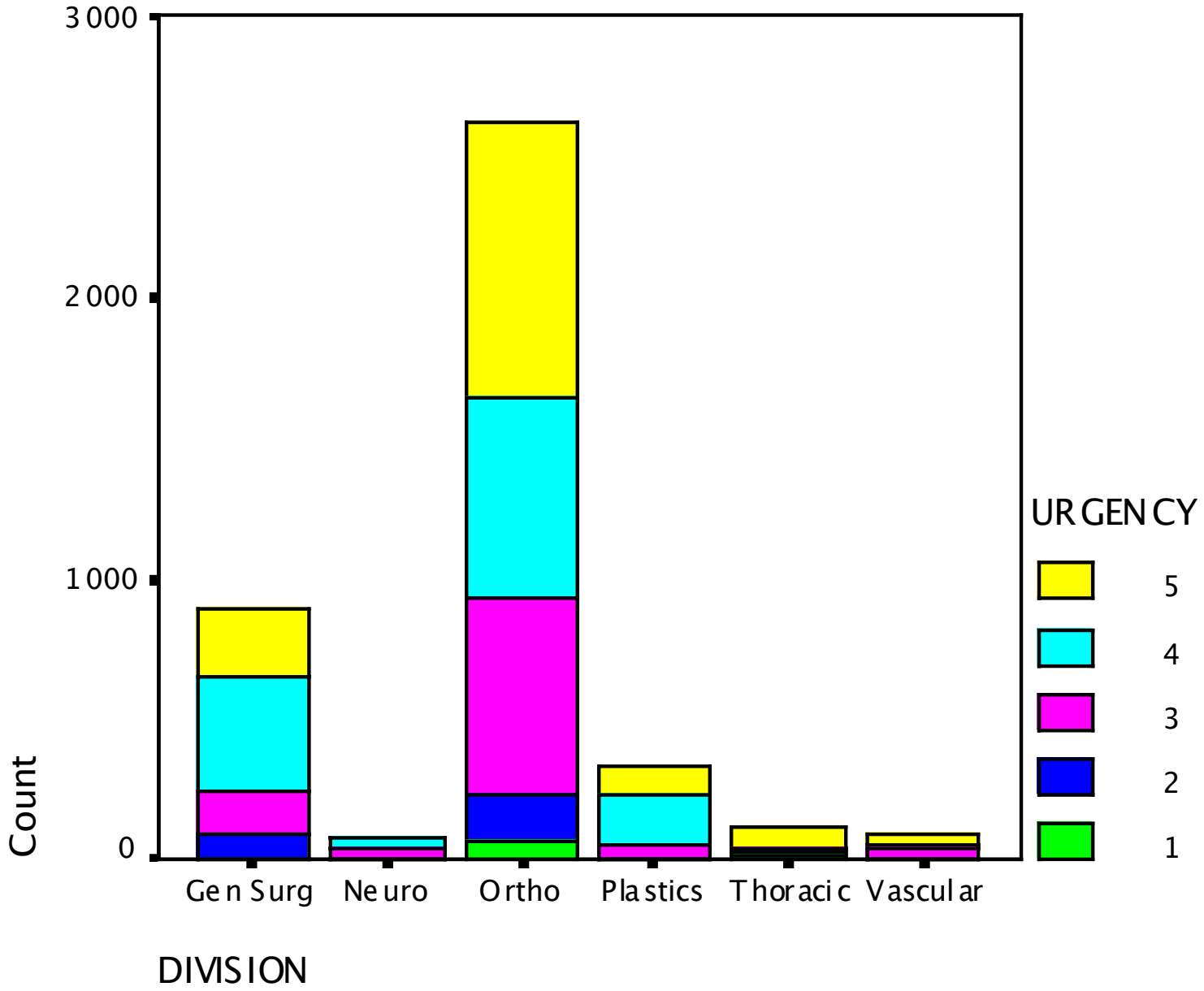
- 25 new Orthopaedic beds
- 1 new OR
- 33 long term care beds opening



DALHOUSIE Orthopaedics



DALHOUSIE
Orthopaedics


3 000
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Count
Gen Surg
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Plastics
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Vascular
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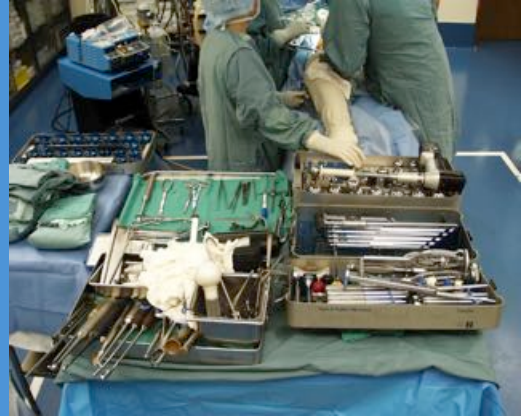
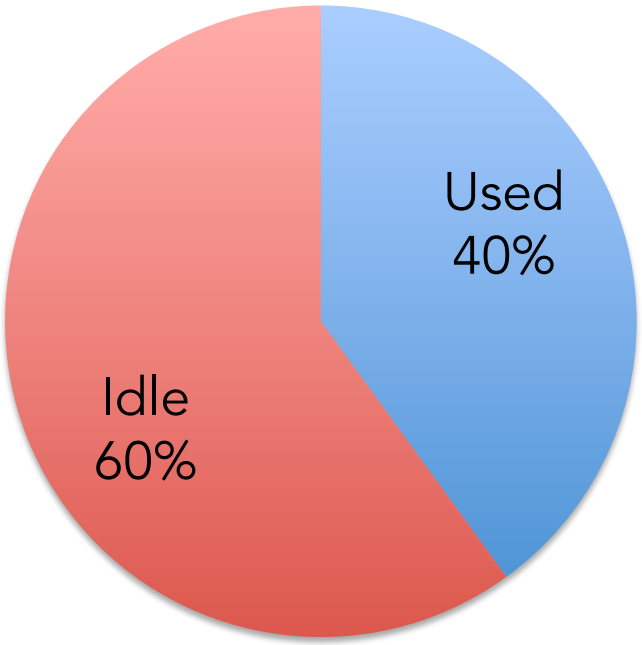
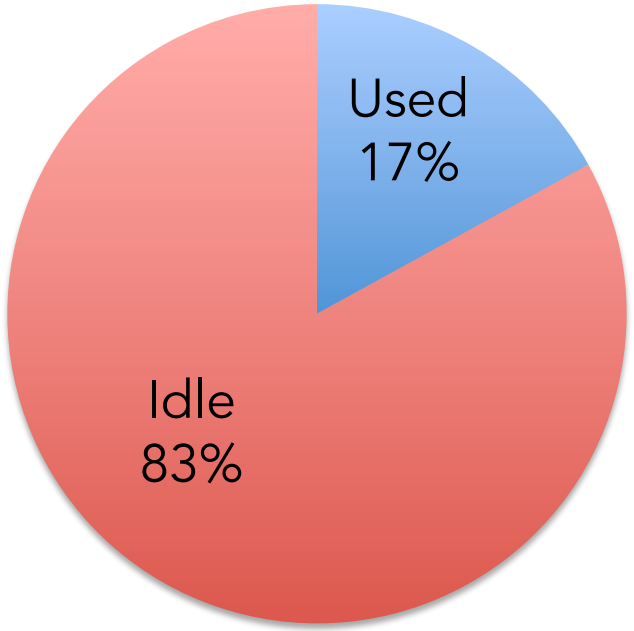
Operating Room Efficiency Problems



- With patient 3.5 - 4.5 hours/day out of 10 hour day



10 Hour Day



24 Hour Day

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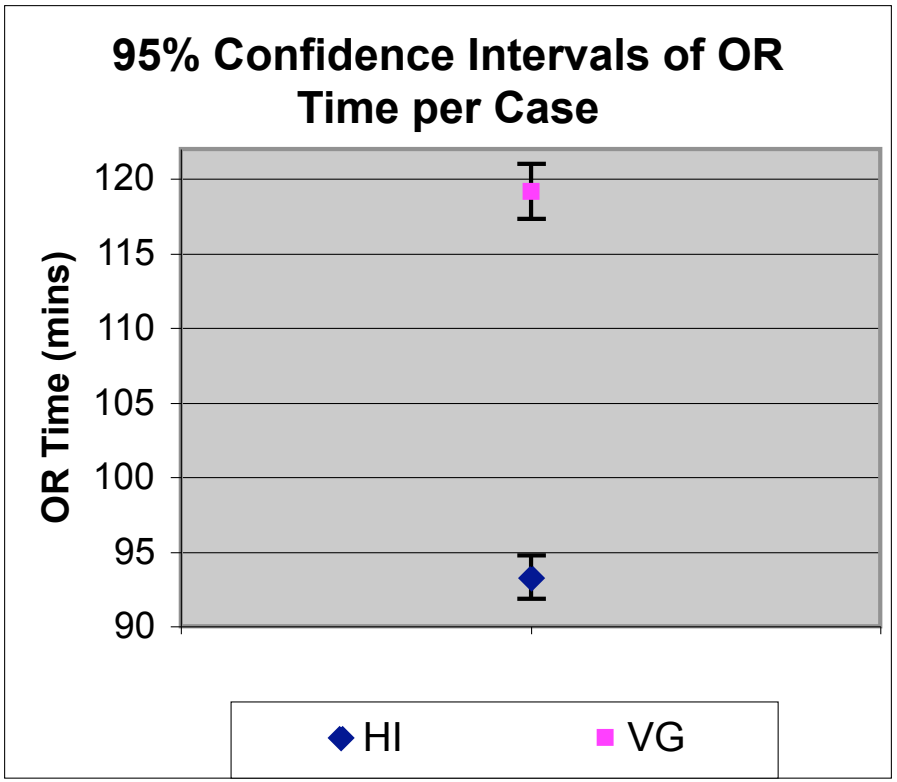
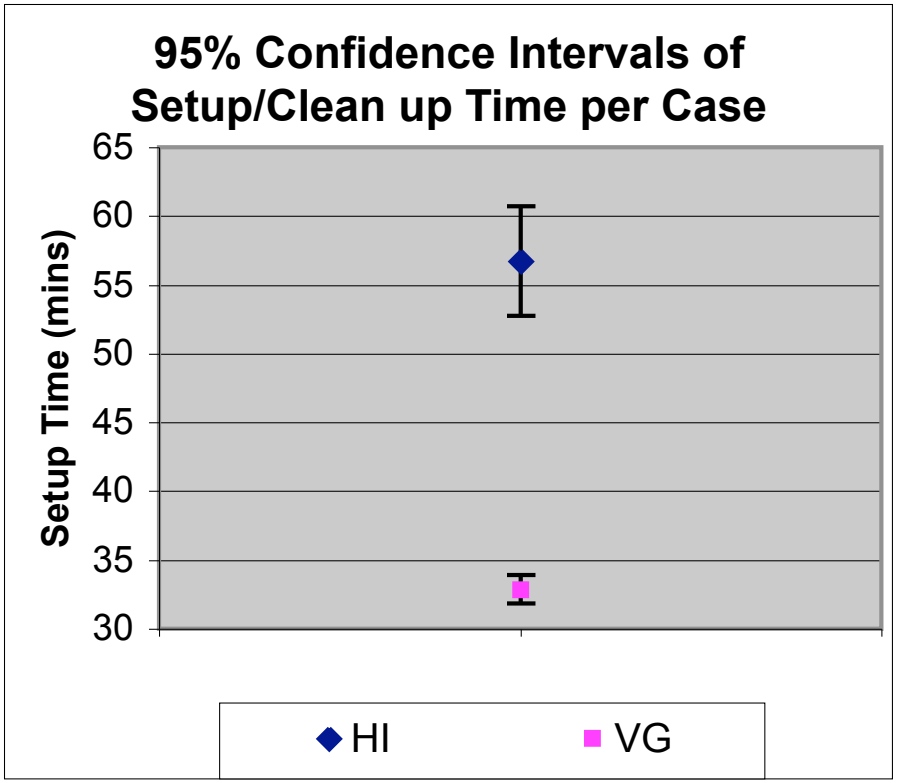
Orthopaedics

Turn Around Time





Site	OR Time (Minutes)	Turn Around Time (Minutes)
HI	93.3	57
VG	119.2	32.9

DALHOUSIE Orthopaedics

NOVA SCOTIA

Nova Scotia Wait Time Information

Knee Replacement

This surgery replaces the knee joint with an artificial joint. The wait time shown is for patients who had their first knee replacement.

Consult **Nova Scotia** 90% of people served within **237** days

Surgery **Nova Scotia** 90% of people served within **660** days

Community	Facility	Consult Wait Time	Surgery Wait Time
Sydney	Cape Breton Regional Hospital	169 days	307 days
New Glasgow	Aberdeen Hospital	308 days	479 days
Dartmouth	Dartmouth General Hospital	236 days	750 days
Halifax	QEII Health Sciences Centre (All Sites)	237 days	799 days
Kentville	Valley Regional Hospital	226 days	884 days

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Orthopaedics

NOVA SCOTIA

Nova Scotia Wait Time Information

Christopher Glen Richardson

Consult **Nova Scotia** 90% of people served within **110** days

Surgery **Nova Scotia** 90% of people served within **1240** days

Procedure	Community	Consult Wait Time	Surgery Wait Time
Hip Replacement	Halifax	107 days	970 days
Hip Replacement Revision	Halifax	---	---
Knee Replacement	Halifax	111 days	1288 days
Knee Replacement - Partial	Halifax	113 days	---
Knee Replacement Revision	Halifax	---	---
Knee Scope	Halifax	94 days	---

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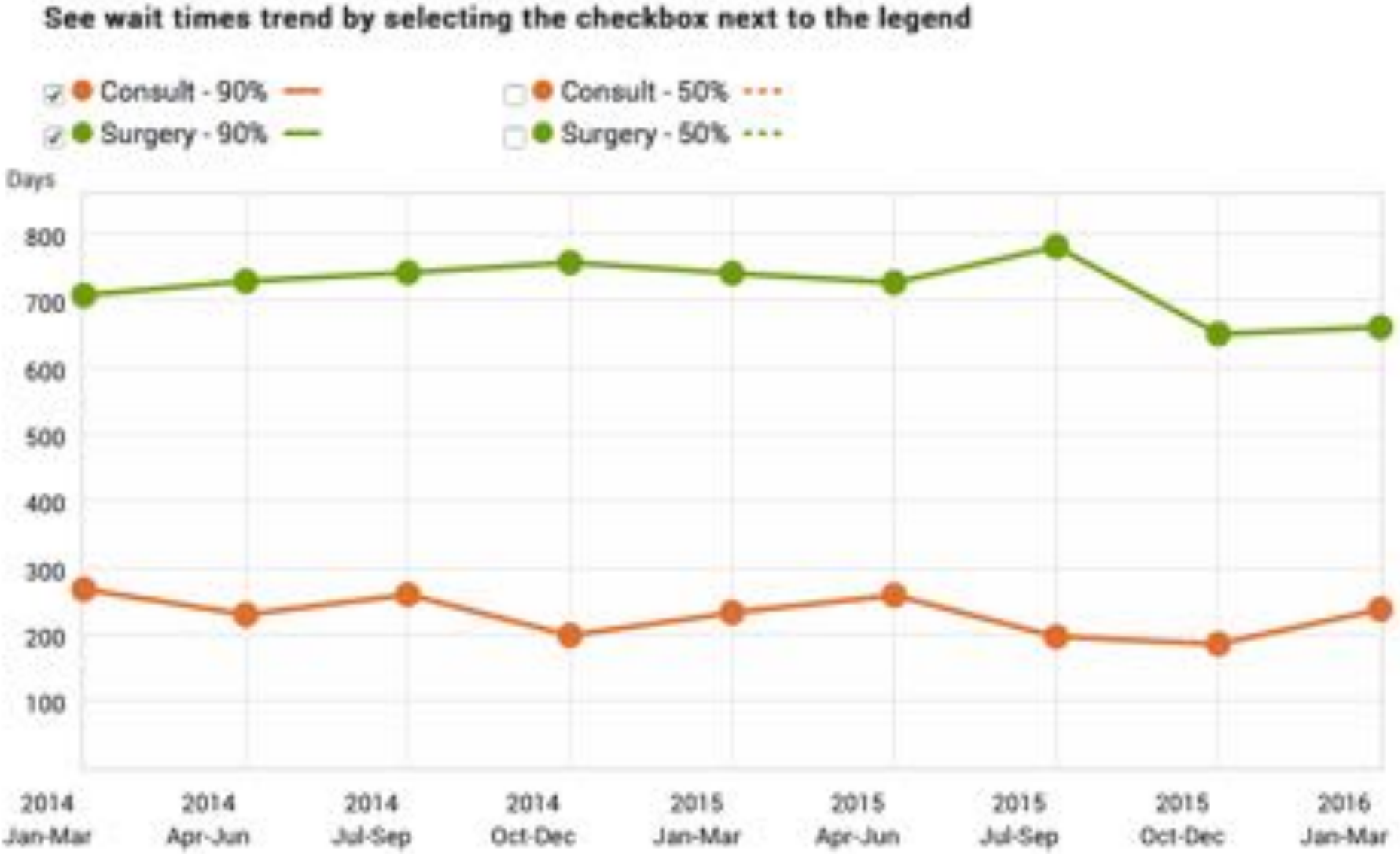
Orthopaedics

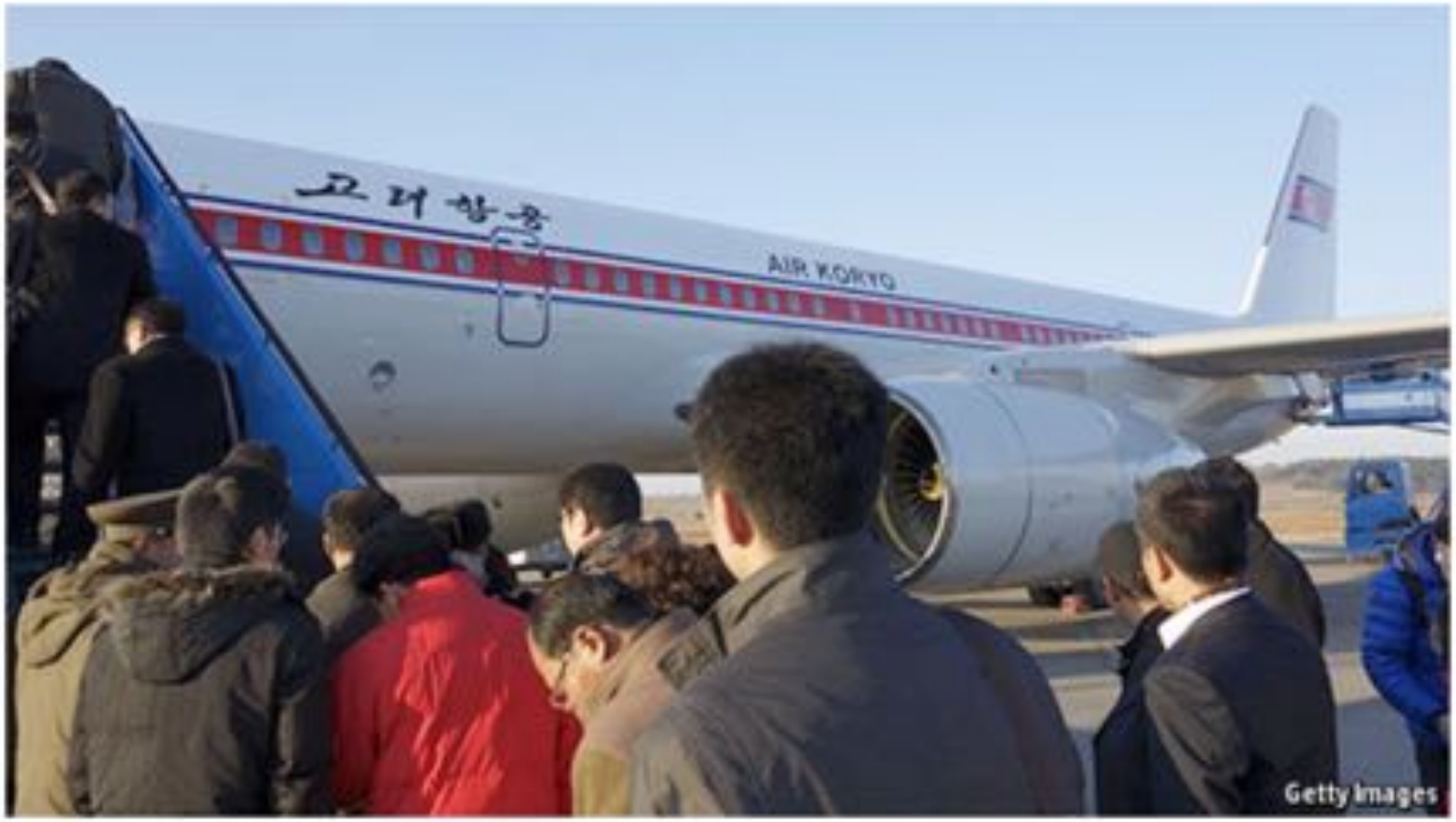


DALHOUSIE Orthopaedics

Aviation in North Korea

Air Koryo: Still the world's worst airline

Sep 16th 2015, 15:07 BY J.J.C.



Recipe for Failure…

- Set rules
- Enforce the rules
- Set the prices
- Eliminate competition

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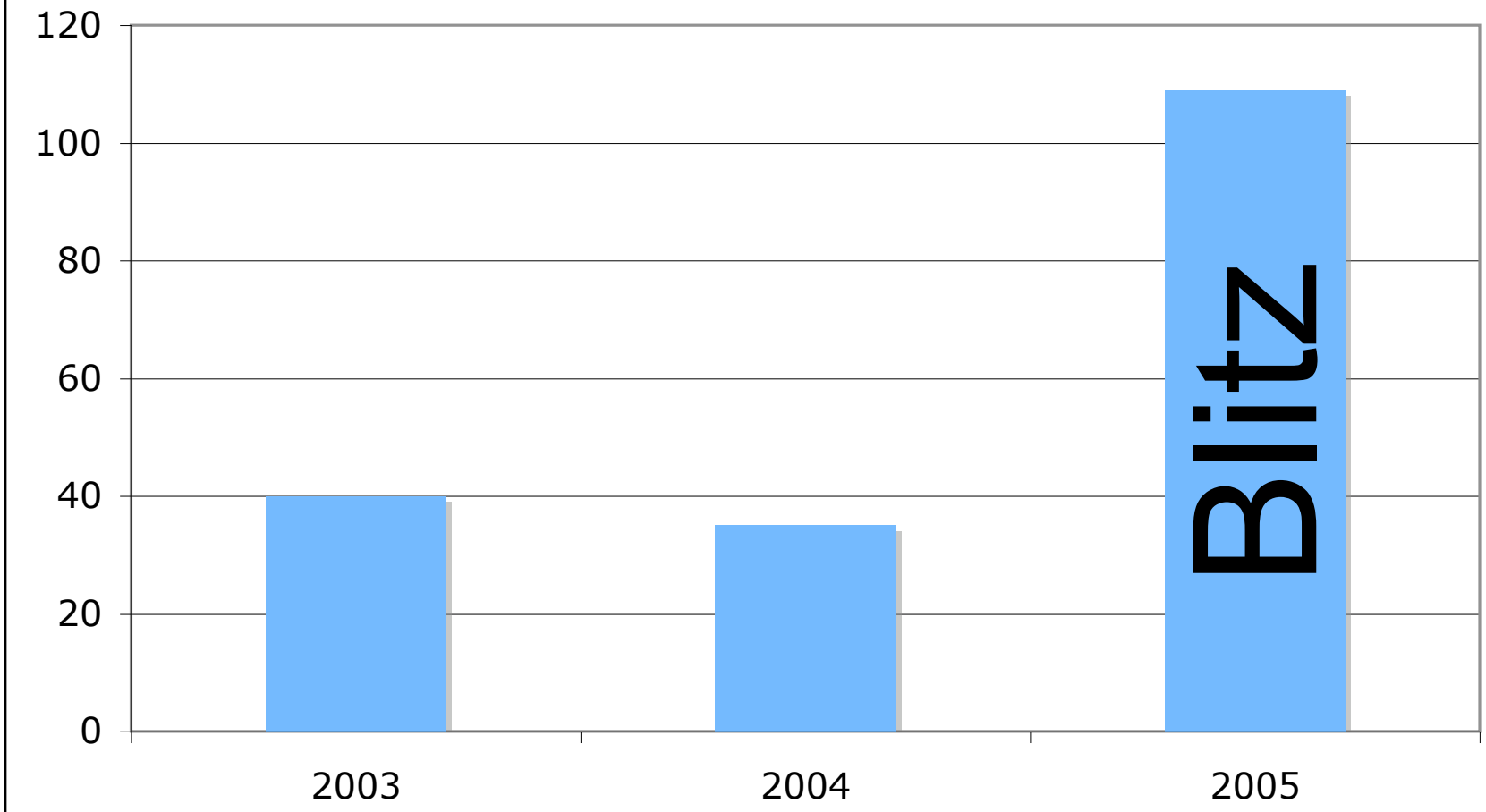
Orthopaedics

Number of Primary Arthroplasties Performed Over Same 2 Weeks



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Cancellations

- No cancellations for run-over
- No increase in OR overtime
- Some rooms completed lists early
- 4 cases/room/day was realized

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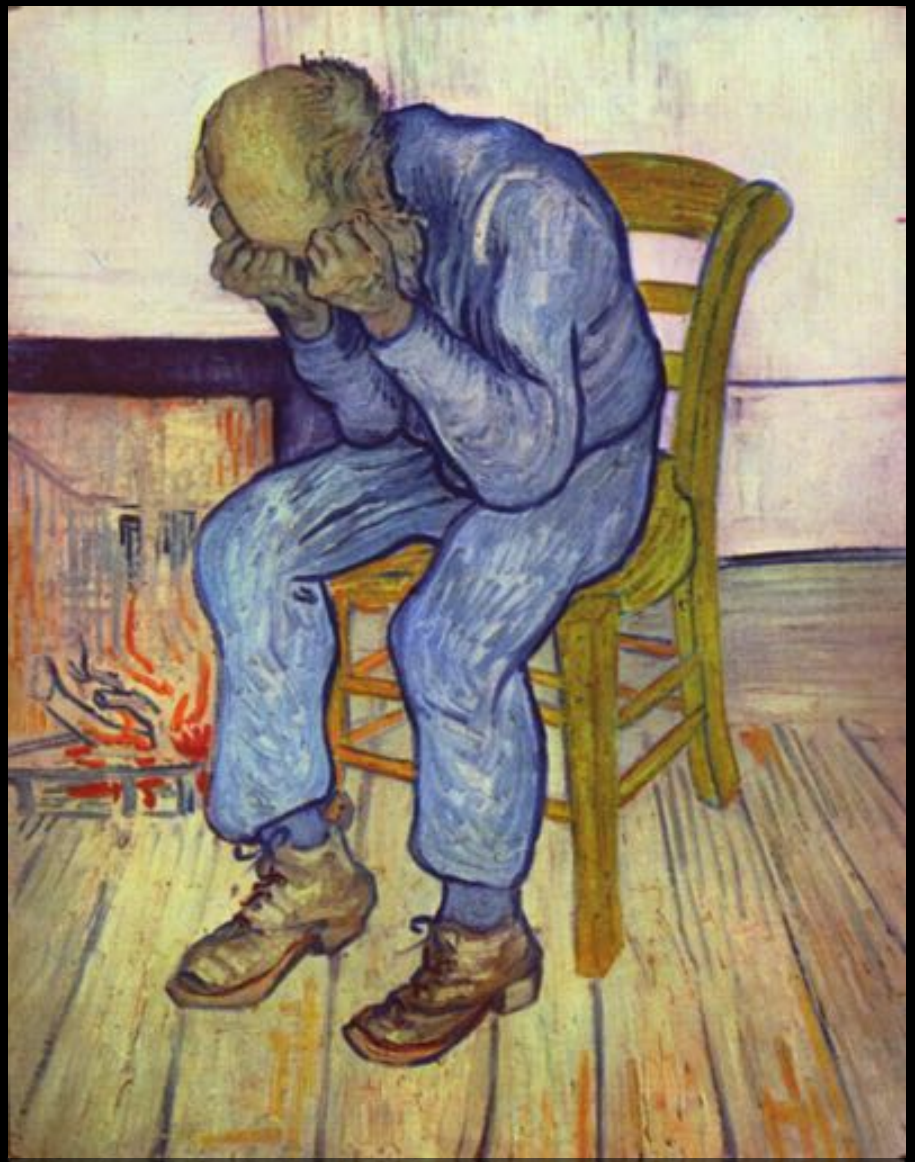
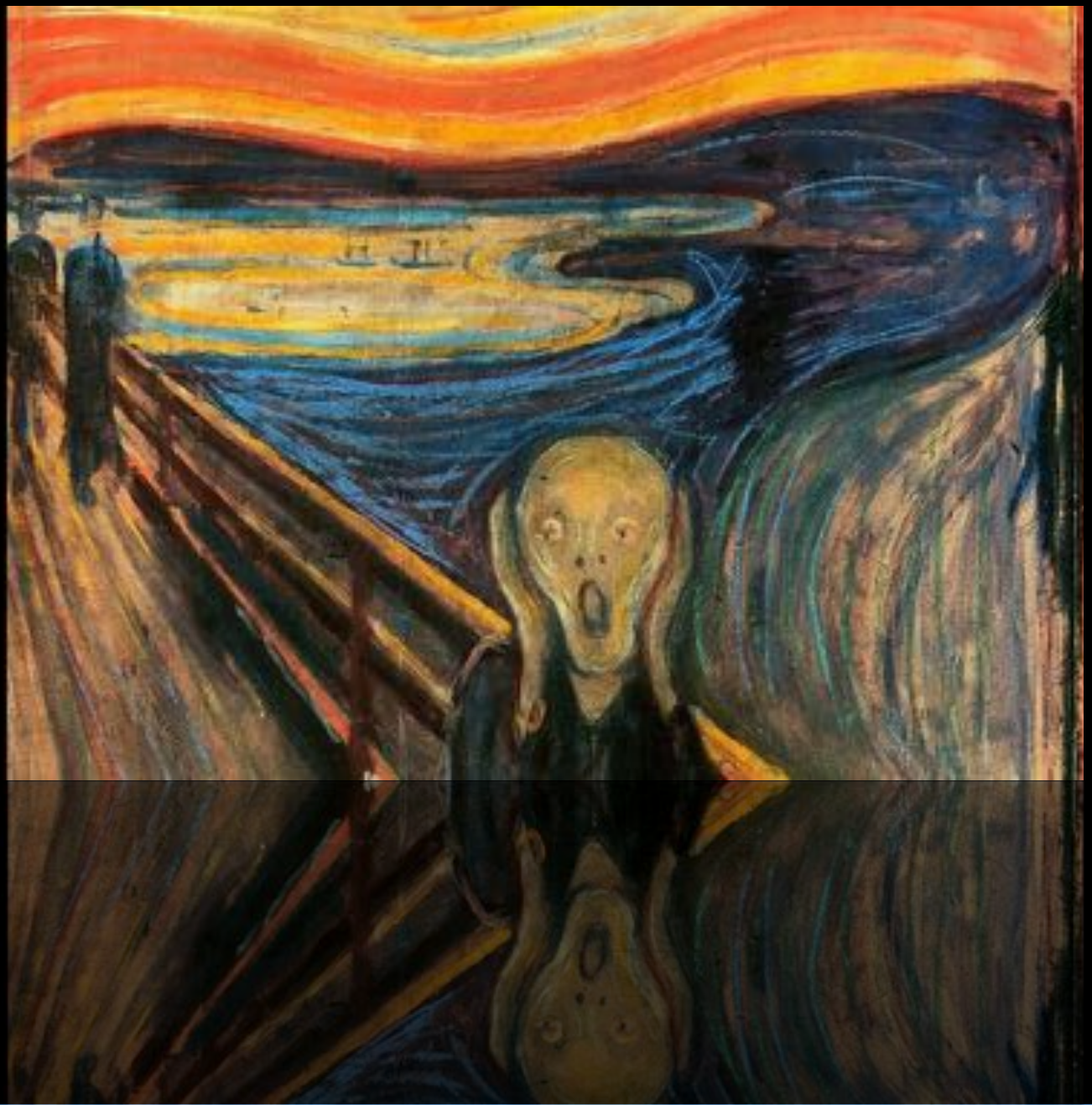
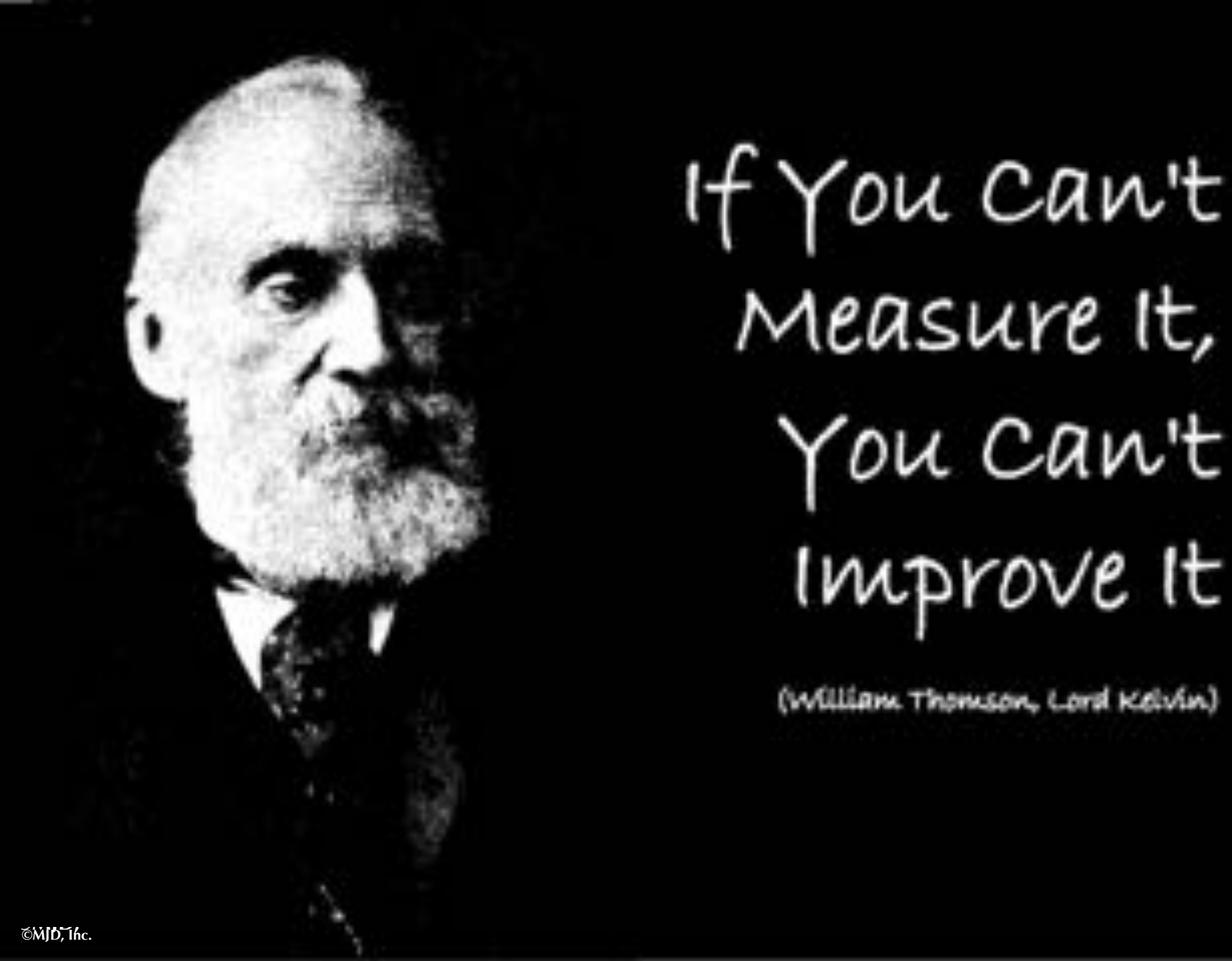
Silo Mentality

- OR budget in silos, no overall coordination for a program, such as hip and knee replacement
  - e.g., cases can be cancelled early, for fear of paying overtime
- Easy to measure some costs
- Hard to measure cost of not doing case
- Costs about to go up!
- Build programs around procedures

DA Orthopaedics

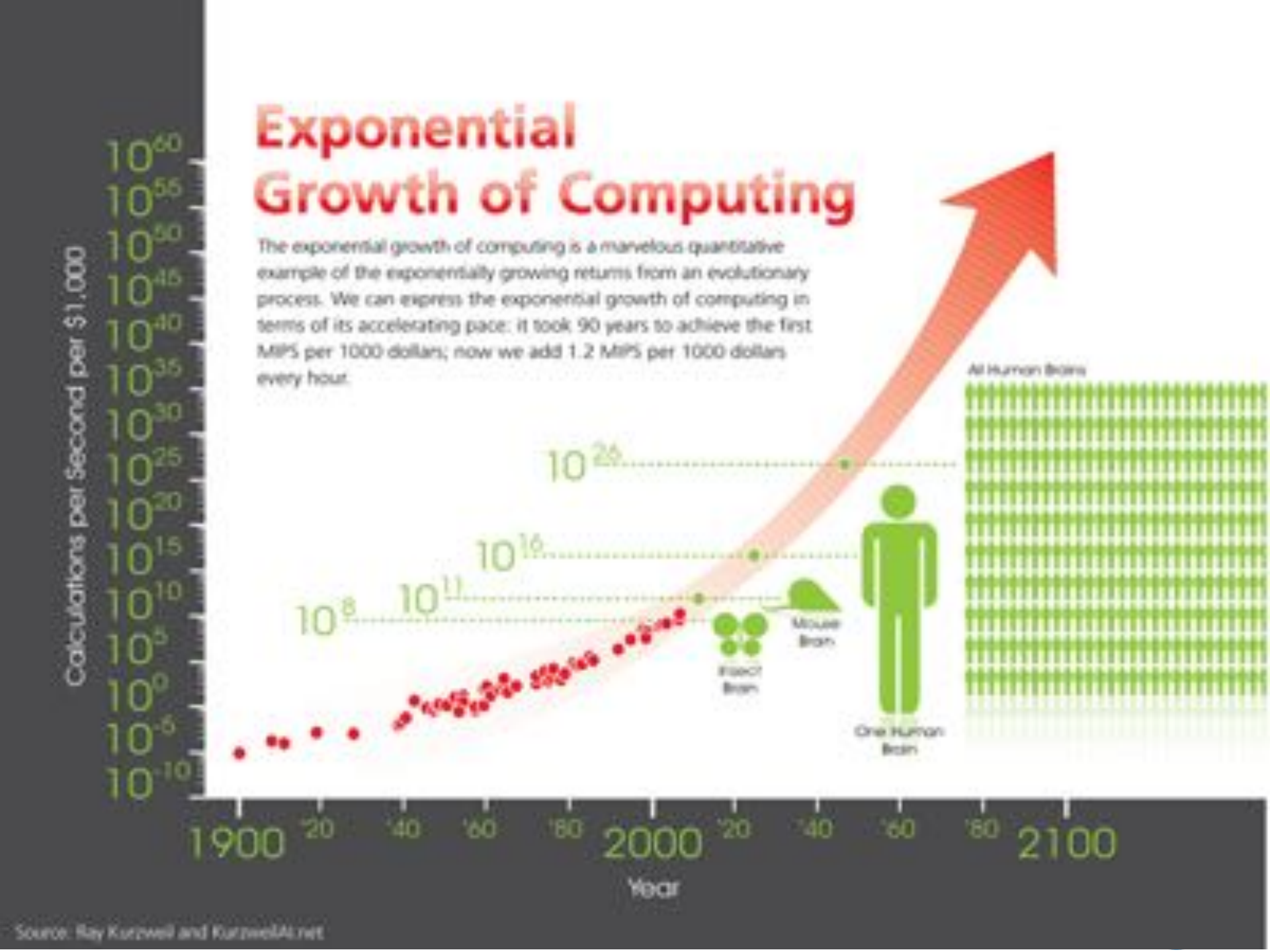




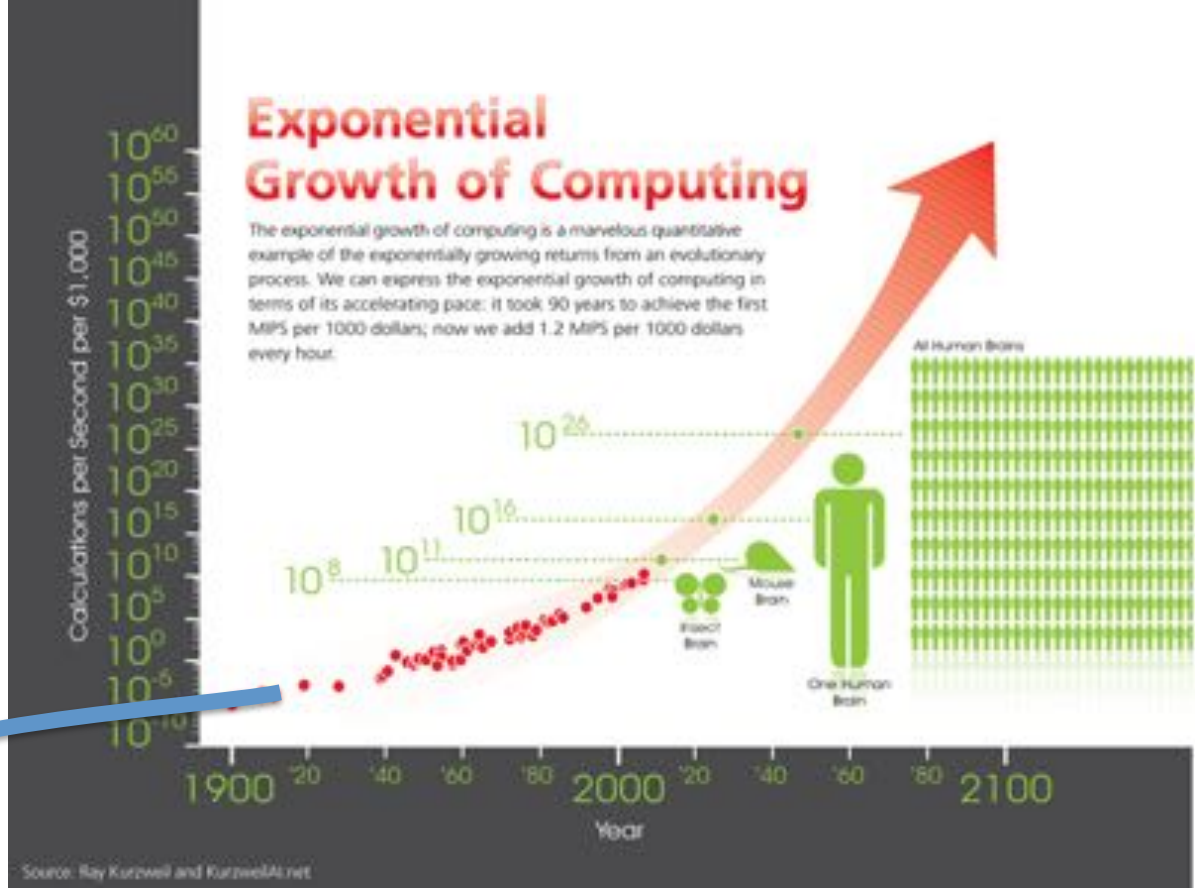

If You Can't
Measure It,
You Can't
Improve It
(William Thomson, Lord Kelvin)

Exponential Growth of Computing

The exponential growth of computing is a marvelous quantitative example of the exponentially growing returns from an evolutionary process. We can express the exponential growth of computing in terms of its accelerating pace: it took 90 years to achieve the first MIPS per 1000 dollars; now we add 1.2 MIPS per 1000 dollars every hour.



Source: Ray Kurzweil and KurzweilAI.net



The best way to predict the future is to invent it

Alan Kay

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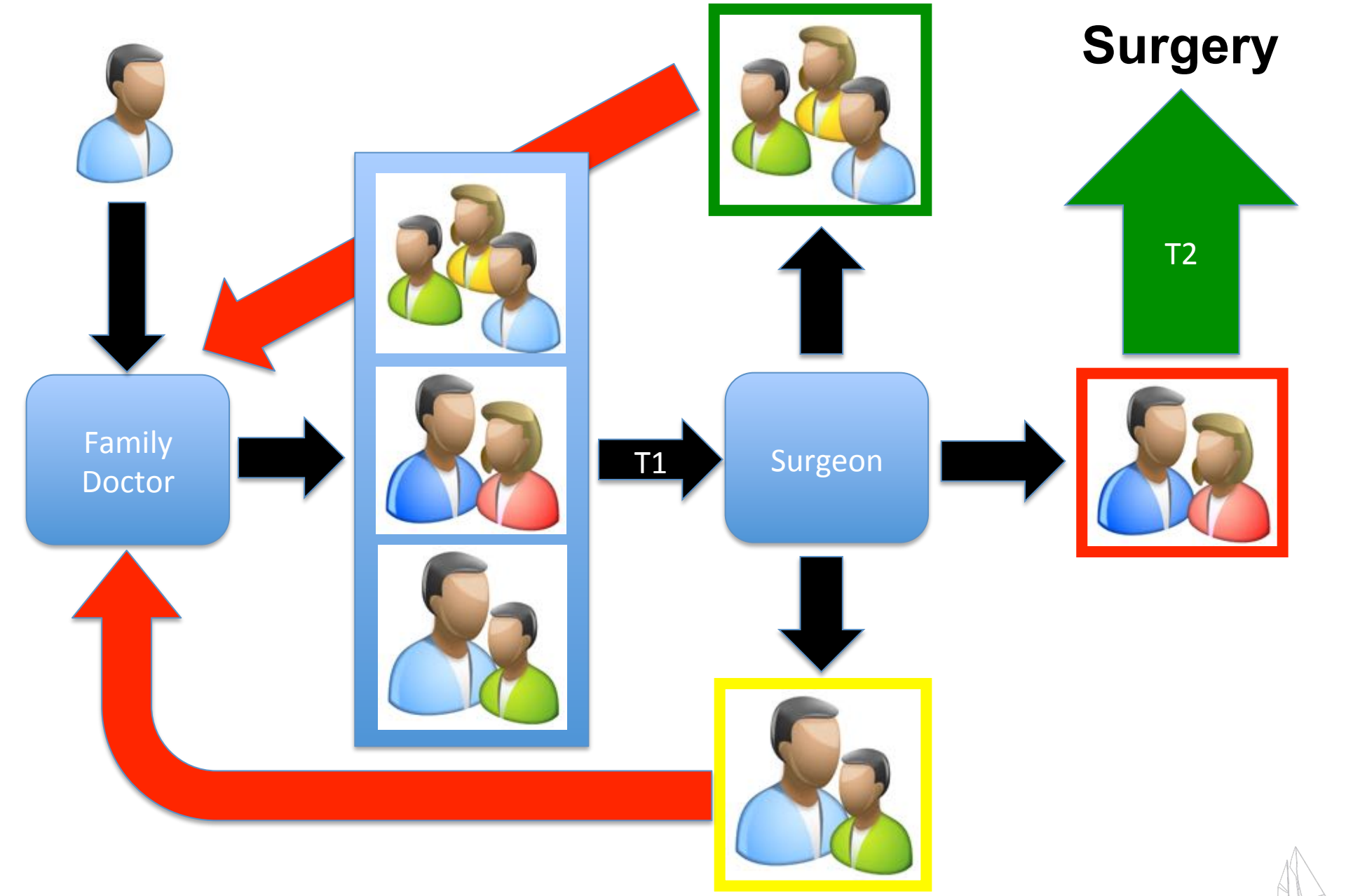
Orthopaedics

2D Modern X-rays?

Roentgen 1895


Surgery
T2
Family Doctor
T1
Surgeon

Alternate Care Models

- Change from vertical to horizontal management structure
- Team building with allied health care
- Under capacity
  - Medi/surgi centres
- Improve outcomes and reduce wait times

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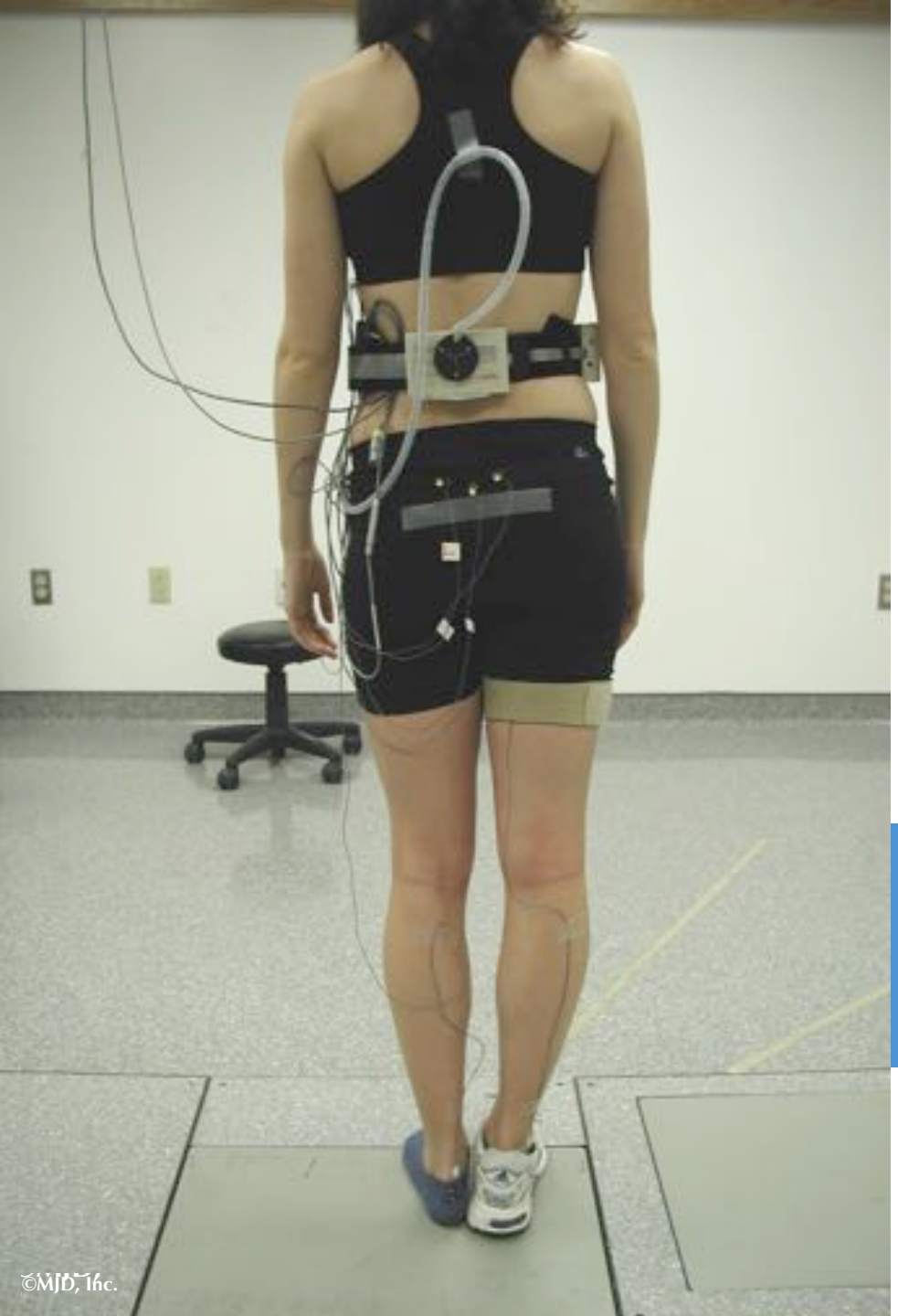
Orthopaedics



Validation

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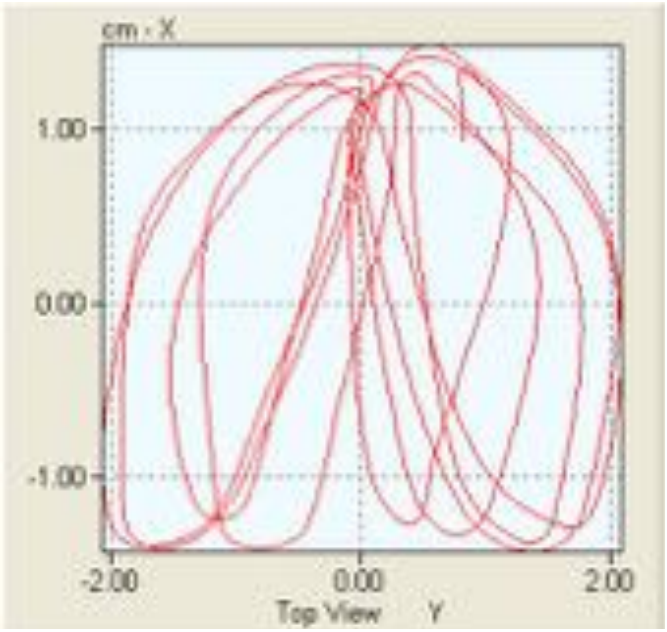
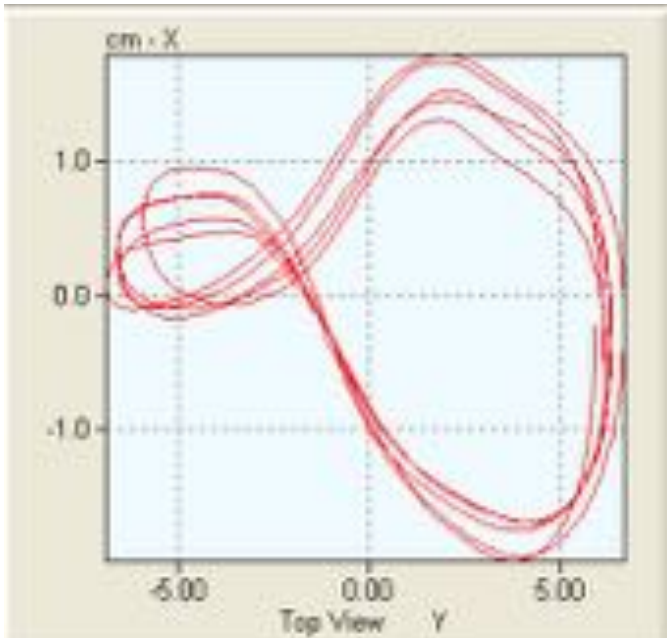
NORMAL HIP



ARTHRITIC HIP



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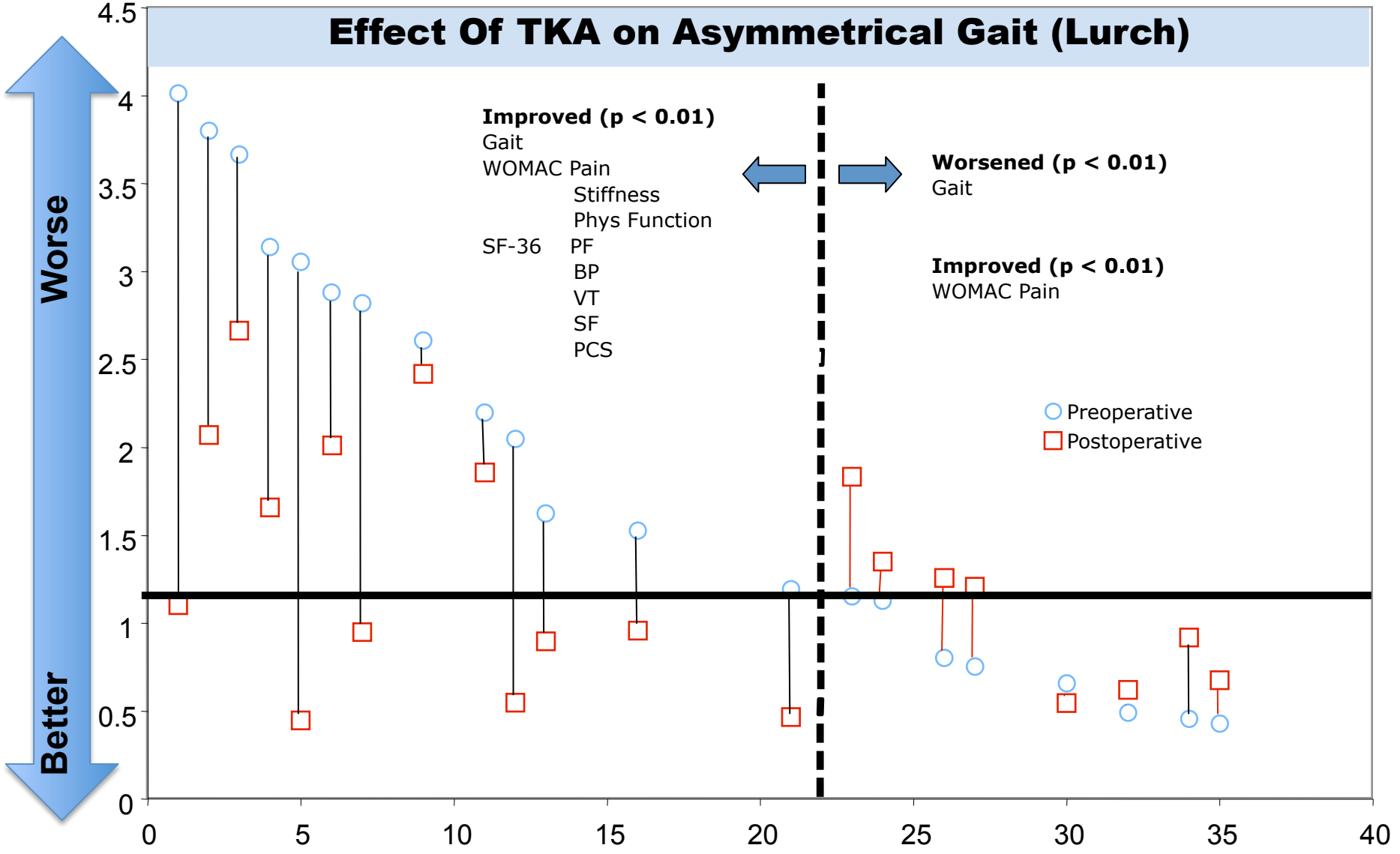

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Wait times? There's an app for that

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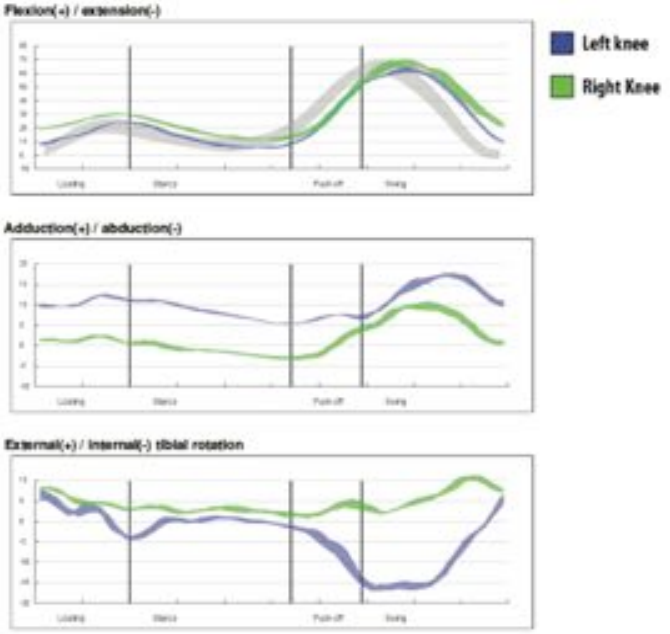
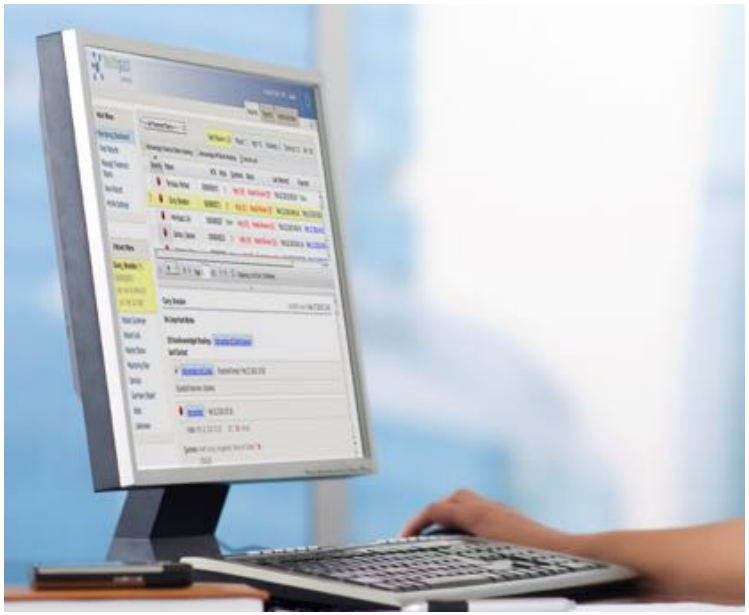
Real time 3D motion visualization





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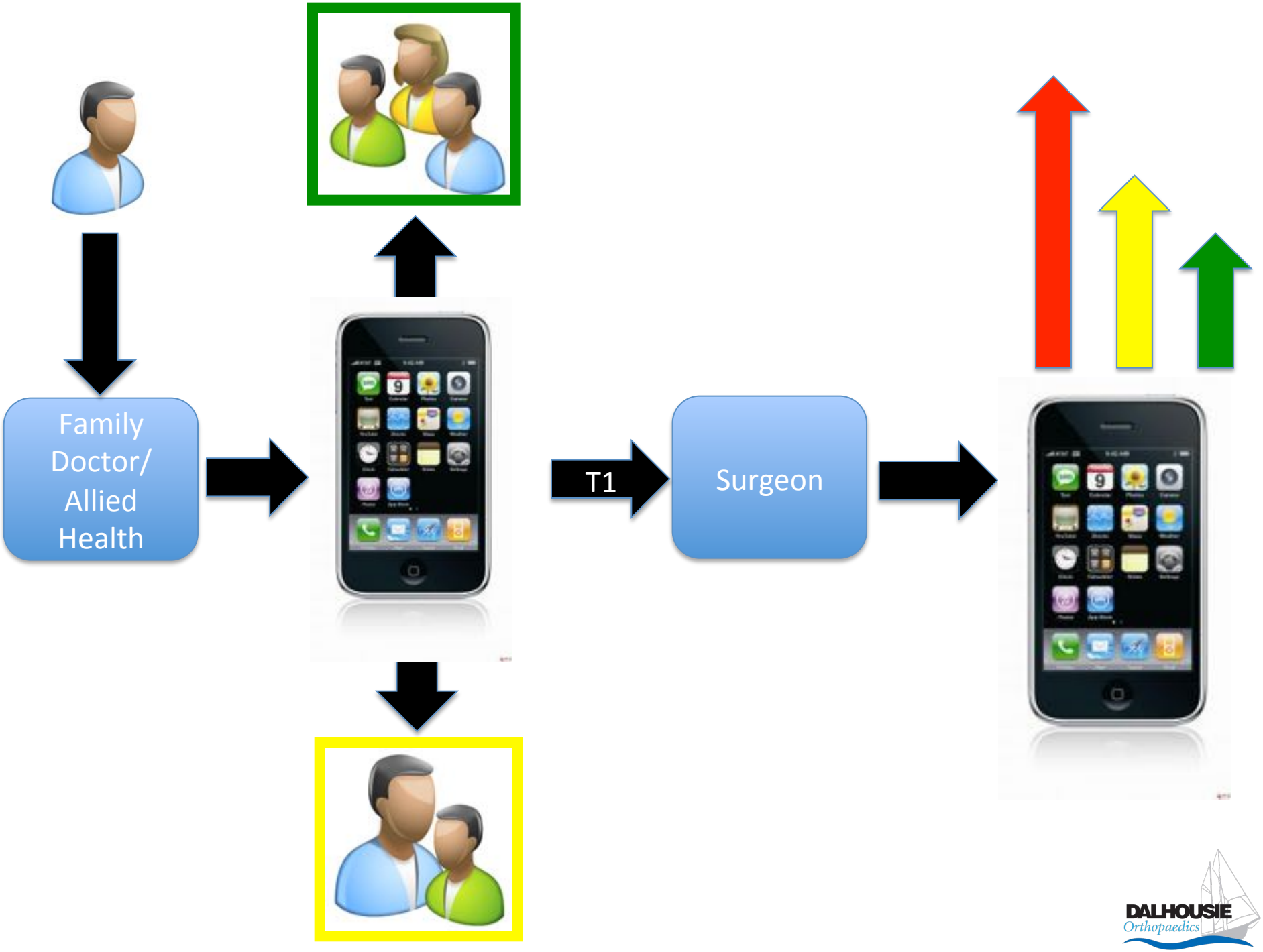
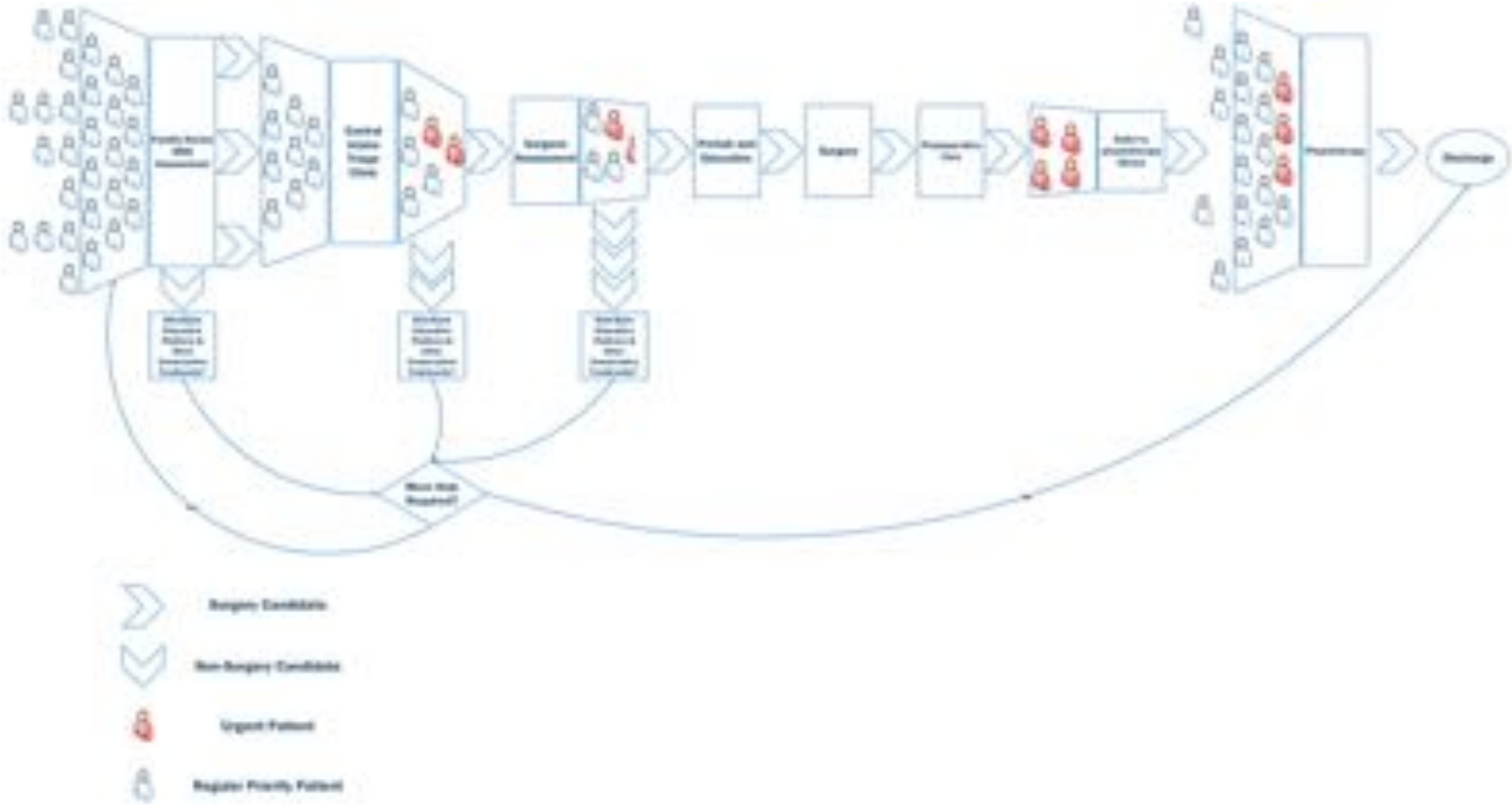
Orthopaedics


Family Doctor/ Allied Health
T1
Surgeon



By Hamed Mirzaei
5th Year Industrial Engineering Dalhousie
Co-op Placement

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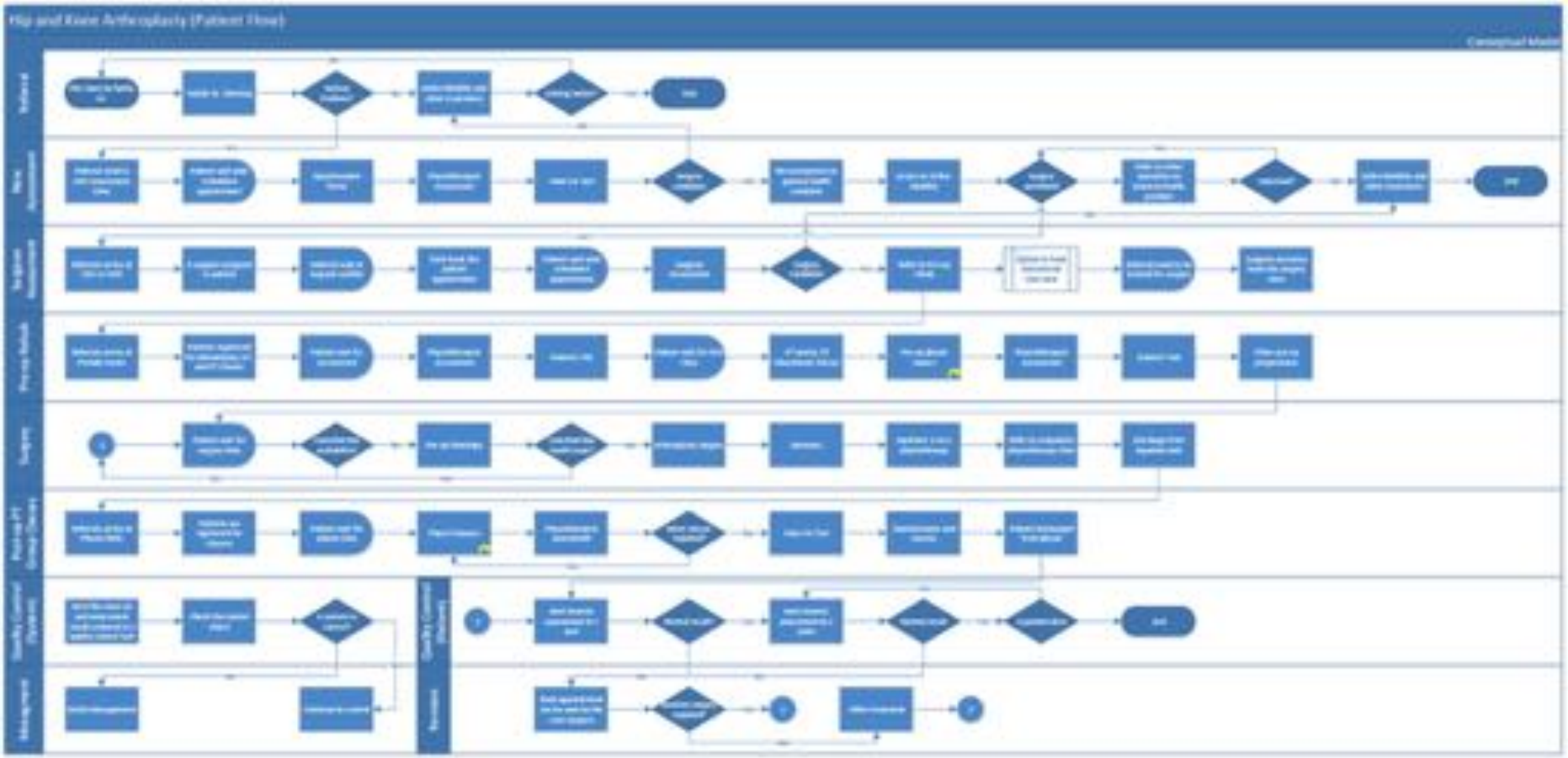
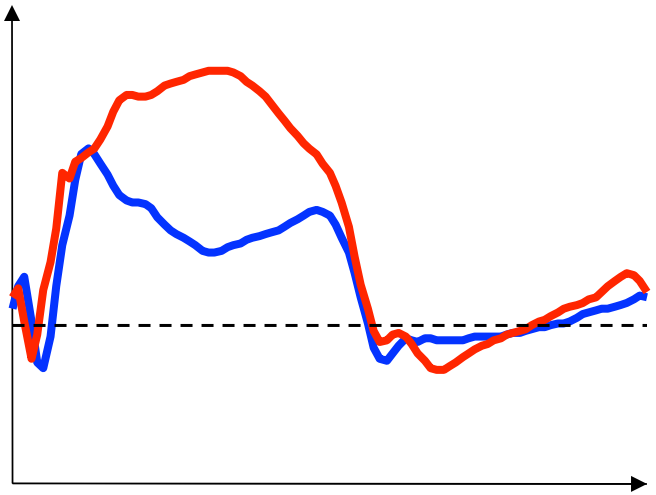
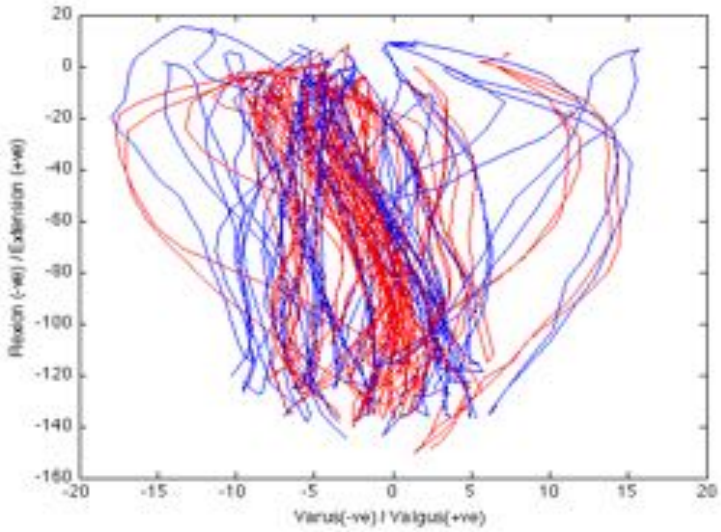
Orthopaedics




+ Y
X
Z
- Y

AIF - Accelerometers as Surrogates





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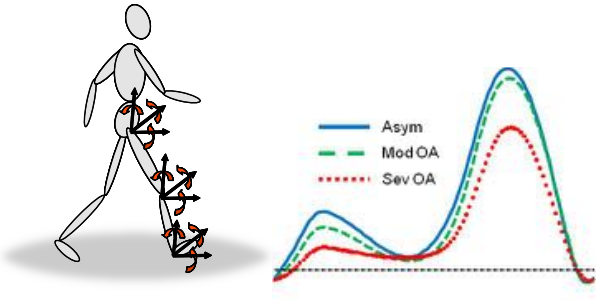
Metrics of Knee OA Progression



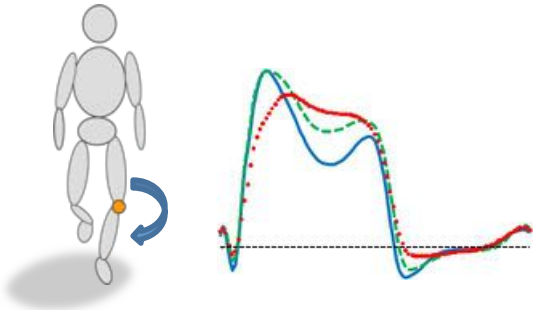
Asymptomatic Moderate OA Severe OA

Knee OA Translational Research: We use cross-sectional and longitudinal progression models to understand how biomechanics change (during gait) with severity and progression of knee OA. We also study specific risk factors such as obesity, female sex, and in vivo measurements of physical activity to see how biomechanics change with these factors. We develop and use sophisticated mathematical tools

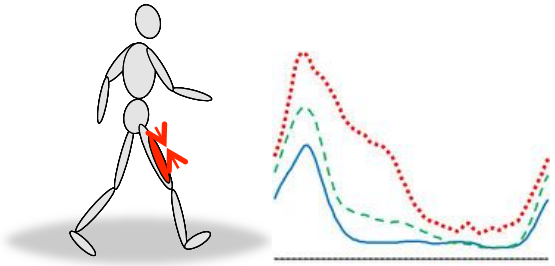
Our goal is to design and validate metrics that can be captured easily either clinically or remotely based on the extensive scientific foundation we have developed.



Kinematics
The pattern of how individuals move their joints during gait changes with OA severity. We see lower peak angles and less range of motion throughout gait.



Kinetics
A key OA variable is the dynamic knee adduction moment during gait. This is the net resultant torque acting on the joint in the frontal plane attempting to push the joint into more varus ('bowlegged') and subsequently loading the medial compartment of the joint. This loading tends to be higher and more sustained during gait in those with knee OA.



Musculature
Those with knee OA have altered neuromuscular control during gait, often characterized by higher and more sustained muscle activations, and often co-activation between muscles.

Astephen et al. 2008; Astephen et al. 2011; Hubley-Kozey et al. 2006; Hubley-Kozey et al., 2009

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Orthopaedics

Phone sensor predicts when thoroughbreds will go lame

› 15 June 2010 by Paul Marks
› Magazine issue 2764. Subscribe and save

YOU might think it would be easy to spot when a horse is going lame. But an inability to walk, trot, canter or gallop with a regular motion on all four hooves can produce subtle or intermittent symptoms, making it hard to decide whether a valuable racehorse or showjumper needs treatment. Now a sensor more often found in smartphones could help provide an early diagnosis.

Sore Point? (Image: Paper Giraffe/Alamy)

The use of technology to study equine locomotion has a distinguished history. Back in 1877, the photography pioneer Eadweard Muybridge used a high-speed camera to show that a galloping horse at times has all four hooves off the ground. The new scheme aims to detect incipient lameness by focusing on the movement of a horse when it is trotting.

BIG DATA

VOLUME
DATA SIZE

VELOCITY
SPEED OF CHANGE

VARIETY
DIFFERENT FORMS OF DATA SOURCES

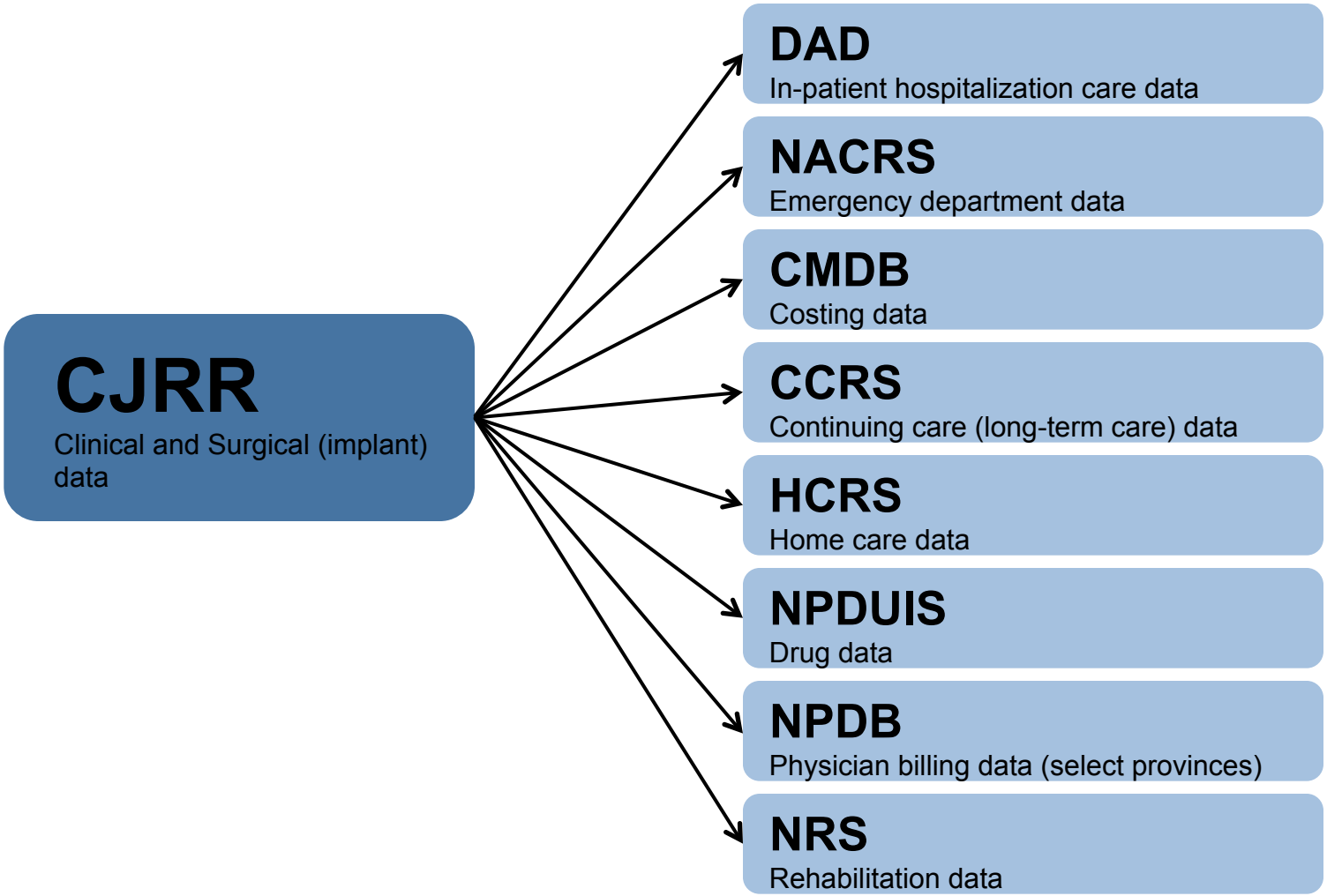
VERACITY
UNCERTAINTY OF DATA

Canadian Joint Replacement Registry (CJRR) Information Package on Implementing Mandatory Reporting

Canadian Institute for Health Information

Institut canadien d'information sur la santé

CJRR Data Can Link To Many Other Data Sources



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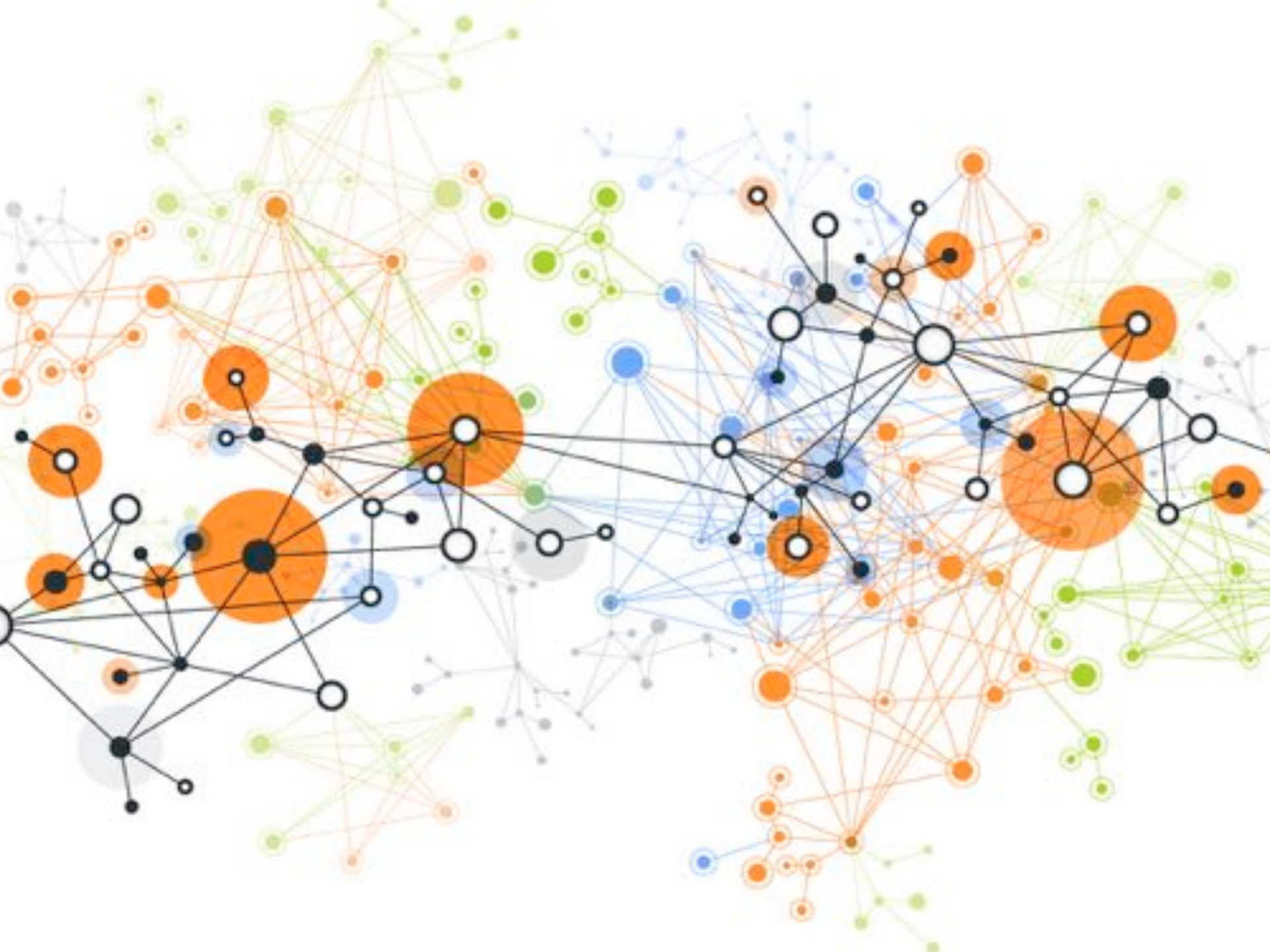
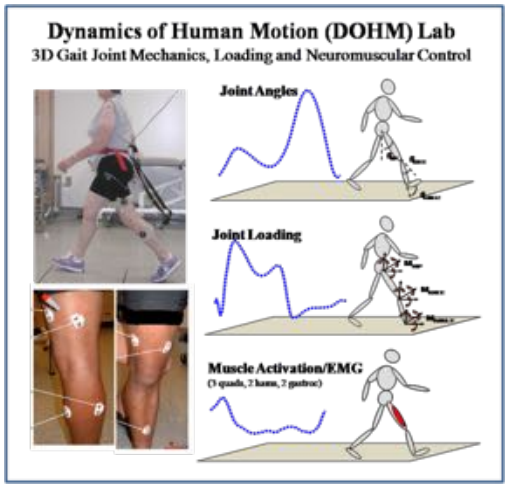
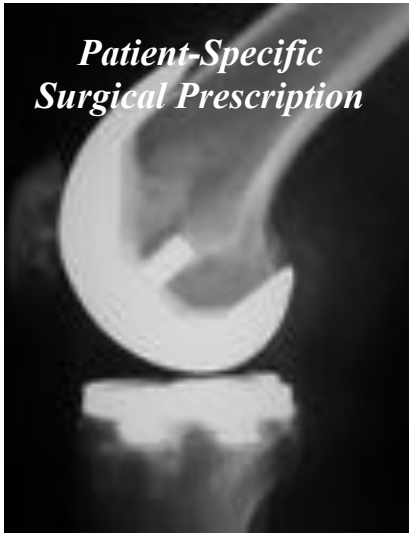


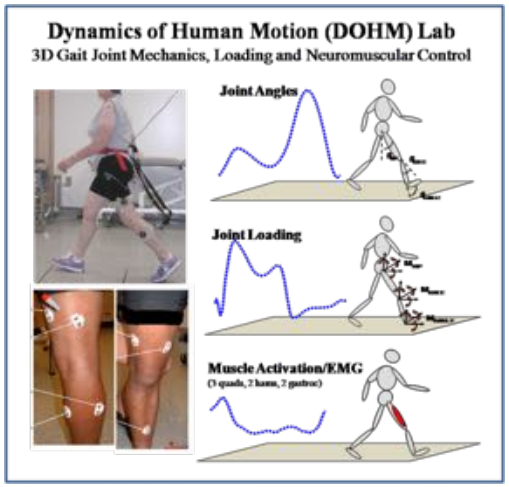
An Objective Framework
TKA Prescription & Assessment

Pre-operative Joint Function
(Dynamic during gait and Passive)





Post-operative Joint Function
(Dynamic during gait and Passive)

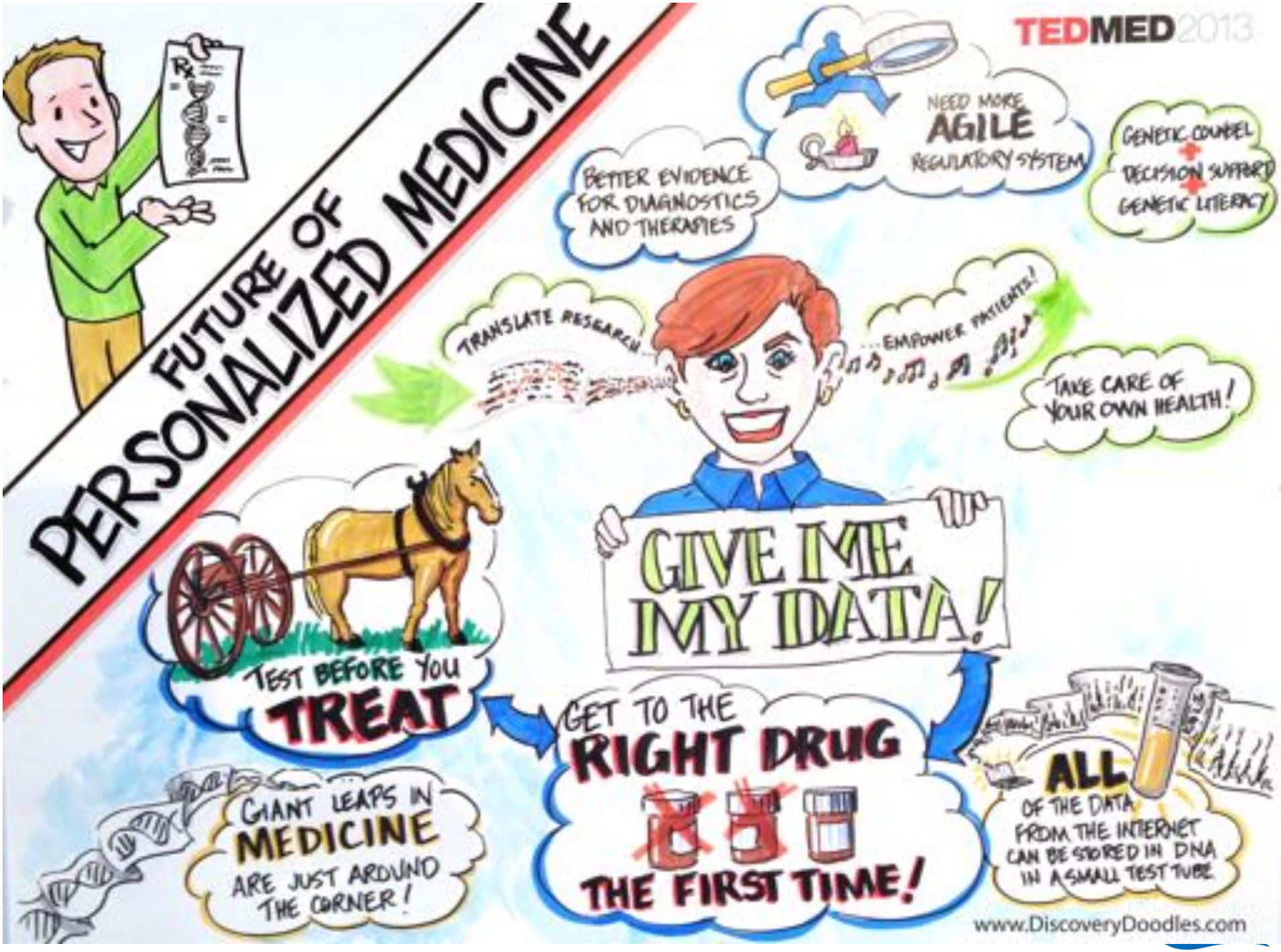


Computer Assisted Surgery

Intraoperative Patient Functional & Morphological Characteristics

Post-Operative Outcome

Radiostereometric Analysis (RSA)


TEDMED 2013
FUTURE OF PERSONALIZED MEDICINE
Rx
BETTER EVIDENCE FOR DIAGNOSTICS AND THERAPIES
NEED MORE AGILE REGULATORY SYSTEM
GENETIC COUNSEL + DECISION SUPPORT + GENETIC LITERACY
TRANSLATE RESEARCH
EMPOWER PATIENTS!
TAKE CARE OF YOUR OWN HEALTH!
GIVE ME MY DATA!
TEST BEFORE YOU TREAT
GET TO THE RIGHT DRUG THE FIRST TIME!
GIANT LEAPS IN MEDICINE ARE JUST ARDUND THE CORNER!
ALL OF THE DATA FROM THE INTERNET CAN BE STORED IN DNA IN A SMALL TEST TUBE
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Gullfoss
1
Selfoss
35
Veiði-
hús
Alviðra
36
350
Torfastaðir II
Torfastaðir I
Írafoss
Veiði
hús
Þing-
vellir
Litli-Háls
Bílds-
fell I-III
Stóri-Háls
Úlfljóts-
vatn
Hlíð
Sog
Úlfljótsskáli
Skátar
Selflatarrétt
Villingavatn
Krókur
Ölfusvatn
360
Hagavík
Þingvallavatn
Nesjar
Nesjavalla-
virkjun
Nesjavellir
Heiðarbær I
Heiðarbær II
Reykjavík
36
Þingvellir
Reykjavík

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Contemplation Before Surgery

Joseph R. Wilder, MD