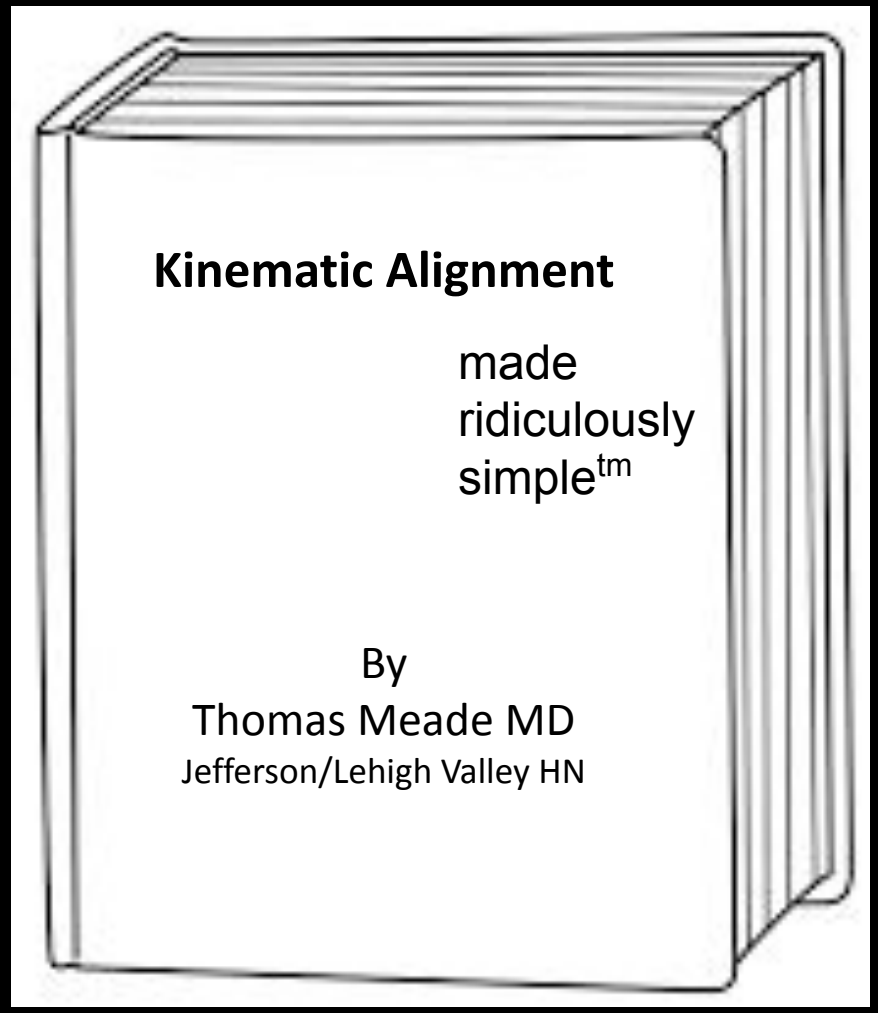

Kinematic Alignment
made
ridiculously
simple™
By
Thomas Meade MD
Jefferson/Lehigh Valley HN

KA-TKA Made Ridiculously Simple

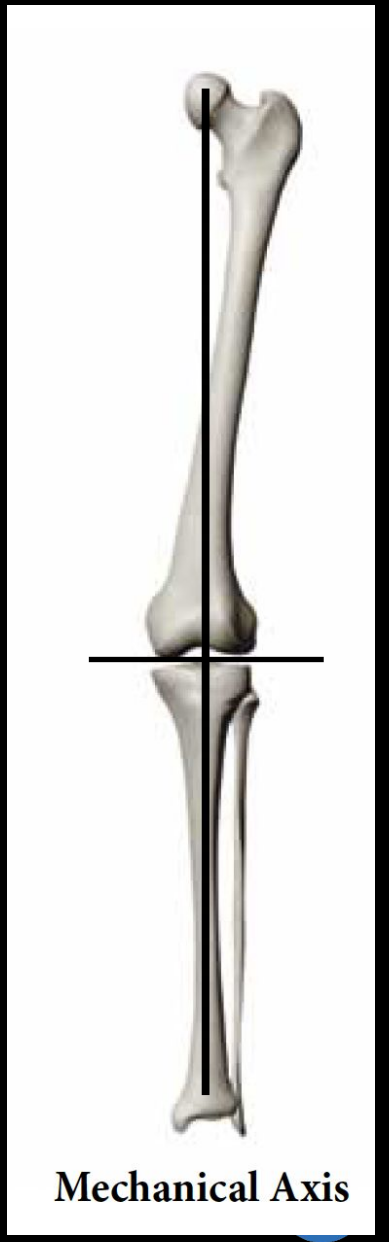
Table of Contents

By
T Meade

Ch.1 Modern Era TKA—1970's---Insall-HSS

- MA-TKA: restore 0^0 degree Hip-Knee-Ankle- ALL PTS

  - Poor material properties
    - primitive implant designs,
    - imprecise instruments
    - no real kinematic understanding- 70"s
  - Standardized carpentry
    - complex matric of healthy ligament releases
  - 3 decades of improvements: SAME OUTCOME
  - Eazy to teach!



TKA patient satisfaction?

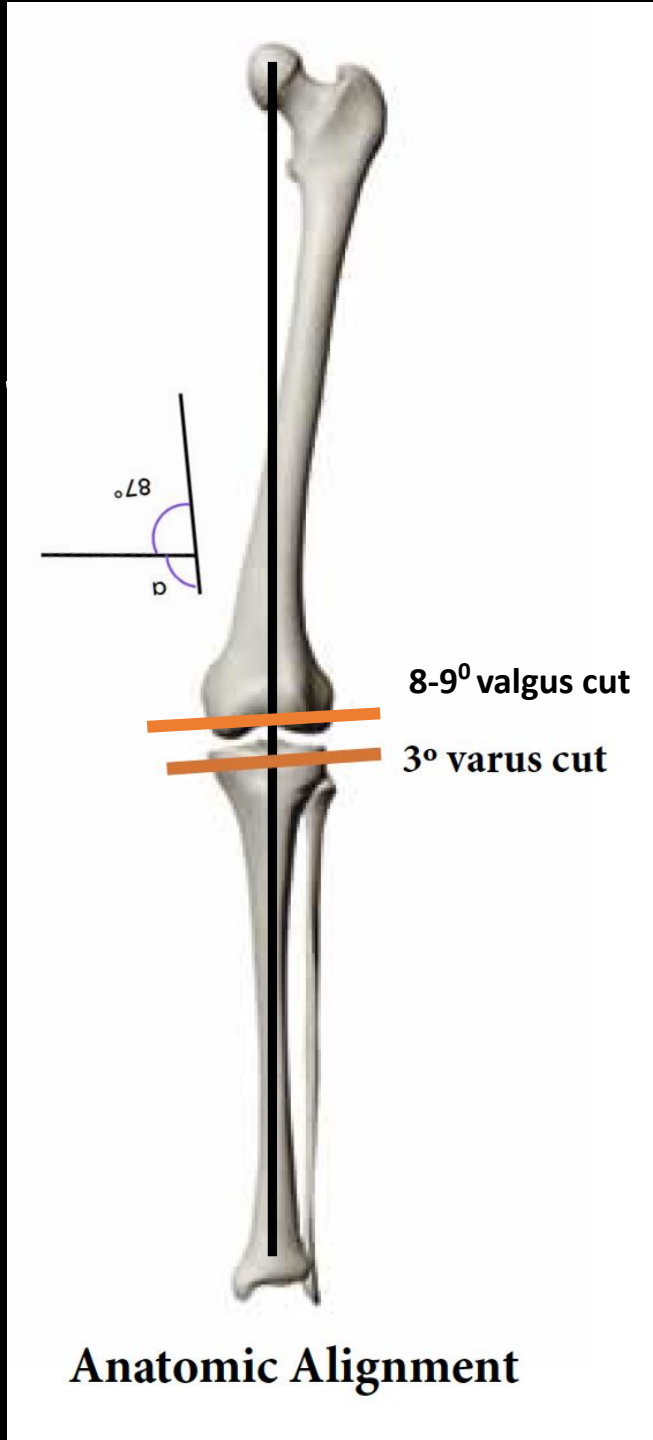
- 1 in 5 patients not satisfied with results of TKA [1,2,3,4]

References:

1. Baker PN, van der Meulen JH, et al. The role of pain and function in determining patient satisfaction after total knee replacement. Data from the National Joint Registry for England and Wales. J Bone Joint Surg Br. 2007; 89(7): 893-900.
2. Noble PC, Conditt MA, Cook KF et al. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. Clin Orthop Relat Res. 2006 Nov; 452: 35-43.
3. Wylde V et al. Patient-reported outcomes after total hip and knee arthroplasty: comparison of midterm results. J Arthroplasty. 2009 Feb; 24(2): 210-6.
4. 1Bourne, R.B., et al; Patient Satisfaction after Total Knee Arthroplasty. Who is Satisfied and who is not? CORR: 2010.

Ch 2.---Why Change?- Data!

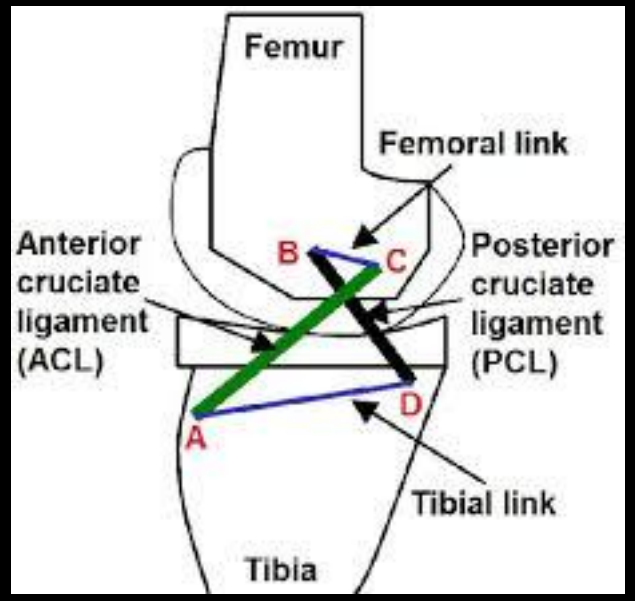
- 1980's- Krakow/Hungerford – need better function
  - Realized Jt line was not parallel to the ground
    - 'Often'- in varus ~ 3^0 so……
  - Anatomic Alignment: 3^0 tibial varus cut, 8-9^0 femoral valgus cut
  - ….but still maintain 0^0 mechanical alignment
    - Problem: imprecise instruments…
      - and imprecise surgeons
  - Result: too many 2-3^0 outliers-
    - Still poor implant designs and material properties
    - Only addressing coronal alignment- not kinematics
    - ….giving credit where credit is due
      - Predecessor KA TKA



Anatomic Alignment

Ch 3. Evolution Sports Medicine– 80's- 90's

- Better understanding knee kinematics
- Preservation /reconstruction ligaments
- UKA- restoring normal anatomy, slope, jt line orientation



4-Bar Linkage

Triple- Varus Knee

Sports Dr's Get it!

- Preserve/reconstruct ligaments
- Release/torn ligaments= instability
- Restore normal anatomy-3D
- Love UKA/s
- Goal: feel like normal knee
- Just Makes Sense
- Lower Volume guys- but used to change

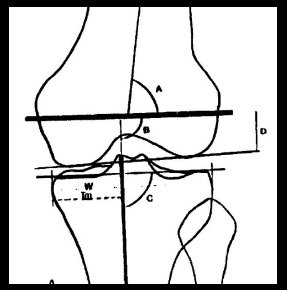
Uni or Kinematic Description??

Uni-Approach

Makes Sense!!

- Restores natural alignment & kinematics
- Removes osteophytes
- Preserves Ligaments
- Replaces worn area w/ components
- Restores Joint Line
- Results:
  - ROM
  - Function
  - Speed Recovery
  - Feels more 'natural'
  - Better Kinematics C-Nav or Conv. TKA (Eckhoff JBJS; Goodfellow JBJS; Pandit JBJS; Hafez CORR; Price J Arth)

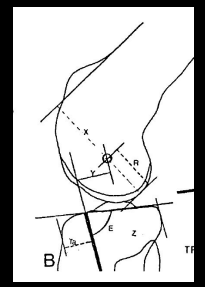
Seminal Kinematic Articles- prior to 2006- after 80's



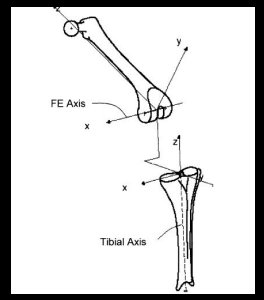
CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 290, pp. 259–268
© 1993 J. B. Lippincott Company

The Axes of Rotation of the Knee

ANNE M. HOLLISTER, M.D., SANJAY JATANA, M.D., ANOOP K. SINGH, F.R.C.S.,
WILLIAM W. SULLIVAN, M.D., AND ANDREI G. LUPICHUK, B.S.E.E.

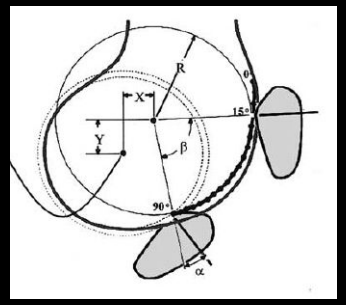


Hollister- Axis of rotation –**1993**



Tibial Axis and Patellar Position Relative to the Femoral Epicondylar Axis During Squatting

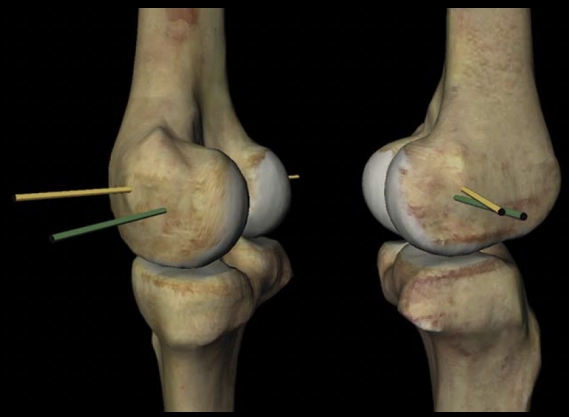
Kathryn M. Coughlin, MS, Stephen J. Incavo, MD, David L. Churchill, PhD, and Bruce D. Beynnon, PhD



Coughlin- Patellar /Tibial Axis-**2003**

THREE-DIMENSIONAL MECHANICS, KINEMATICS, AND MORPHOLOGY OF THE KNEE VIEWED IN VIRTUAL REALITY

BY DONALD G. ECKHOFF, MD, MS, JOEL M. BACH, PHD, VICTOR M. SPITZER, PHD,
KARL D. REINIG, PHD, MICHELLE M. BAGUR, BS, TODD H. BALDINI, MS, AND NICOLAS M.P. FLANNERY, BS



Eckhoff-3-D Kinematics- **2005**

Normal Population Alignment

Three-Dimensional Mechanics, Kinematics, and Morphology of the Knee Viewed in Virtual Reality

Donald G. Eckhoff, Joel M. Bach, Victor M. Spitzer, Karl D. Reinig, Michelle M. Bagur, Todd H. Baldini and Nicolas M.P. Flannery

J Bone Joint Surg Am. 87:71-80, 2005. doi:10.2106/JBJS.E.00440

- Only 2% of normal limbs have 0^0 hip-knee-ankle axis

- Striving for 0^0 hip-knee-ankle axis changes joint line and limb from normal in 98% of patients,

- which kinematically malaligns the knee

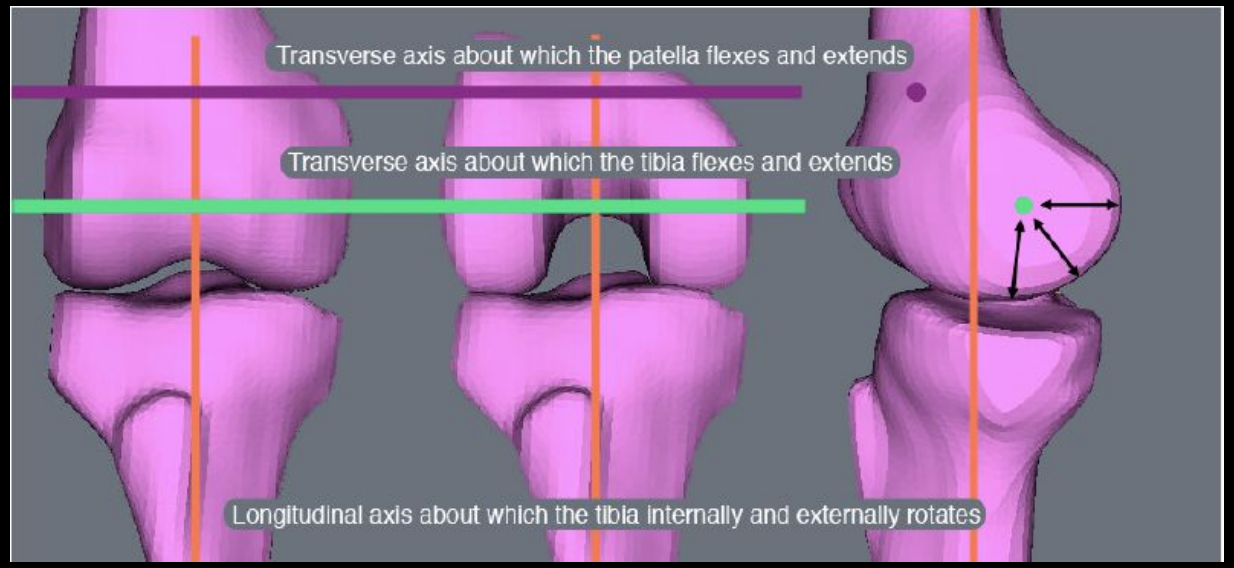
Disruptive Innovation

- Disregard for the patient's natural alignment/kinematics
- Similar clinical outcomes of the conventional and computer- assisted techniques
- Suggest: the need for a new surgical approach with a different alignment

Ch 4. Enter Dr Howell-2006

- Improved materials, implant, instruments, sizes-SAME OUTCOMES
  - ONLY ALIGNMENT PRINCIPLES- MA-NEVER CHANGED
- Translate basic science kinematic principles into clinical practice?
- Reproducing & Restoring Pt's normal & individual 3-D Kinematics
  - MAKES COMMON SENSE -SHOULD IMPROVE OUTCOMES

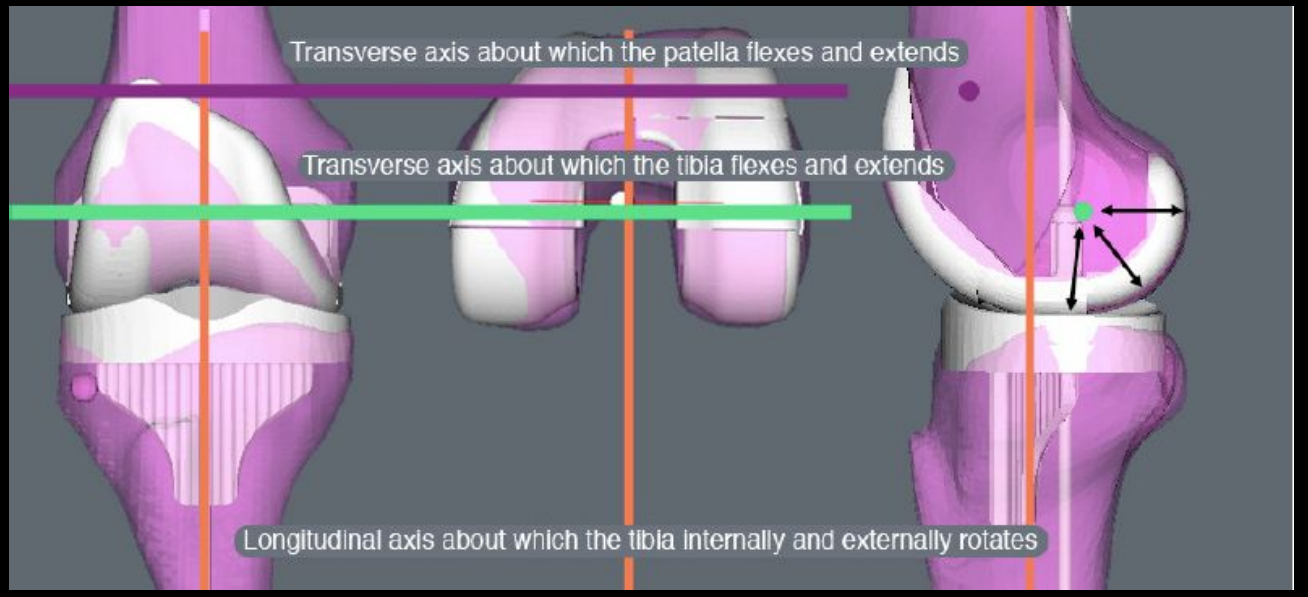
What is Kinematic Alignment in TKA?



- **Kinematics of the knee**: determined by the interaction between the ligaments, menisci, and articular surfaces of the femur, tibia, and patella in space-described by 3 kinematic axes

  - Kinematics of the knee have **nothing to do with the center of the hip or ankle!!**
  - **GOAL: Restore 3 Axes**

What is Kinematic Alignment in TKA?

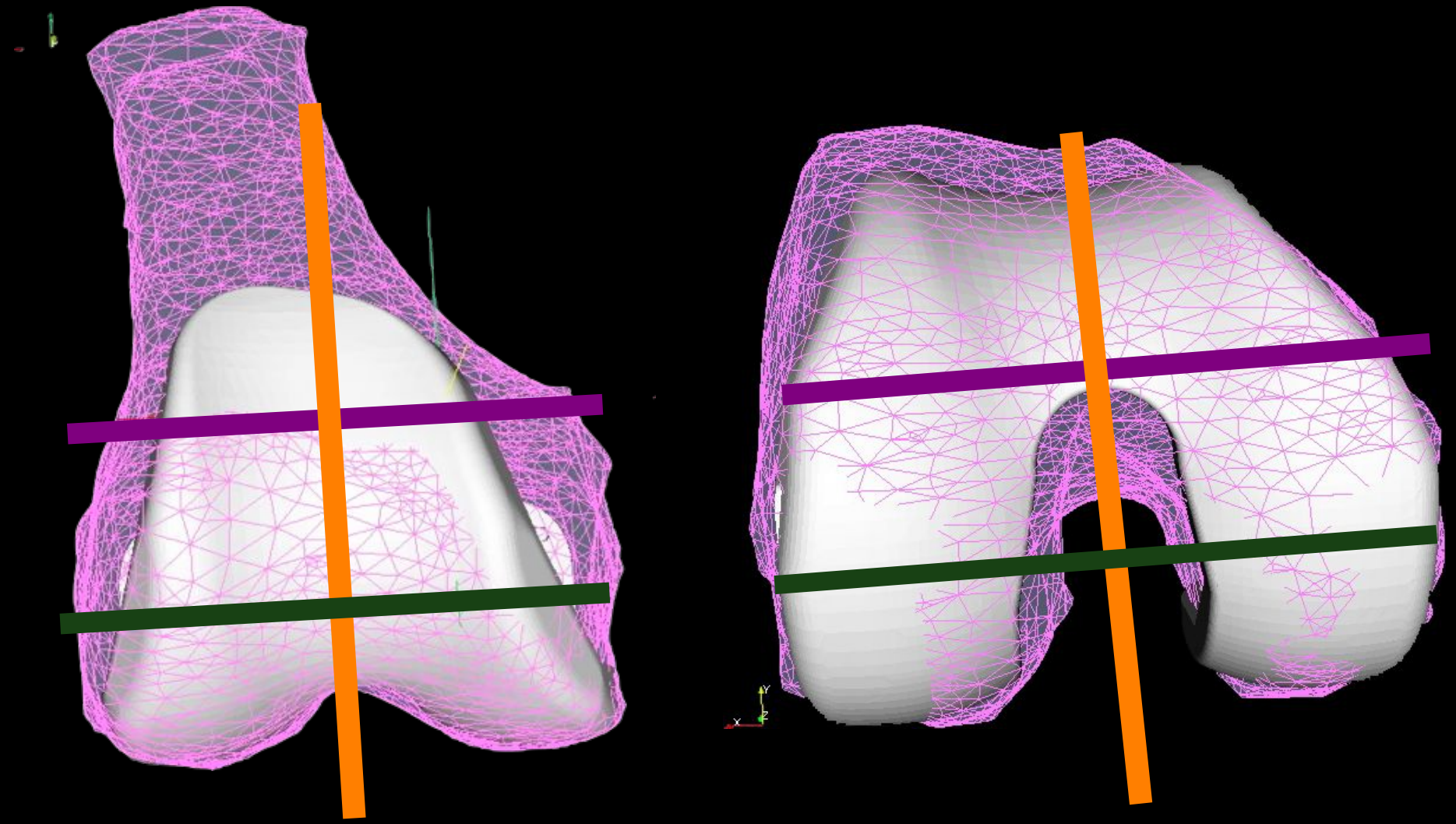


Goal 1:Restore the Natural Tibial-Femoral Articular Surfaces
(Pre-arthritic)

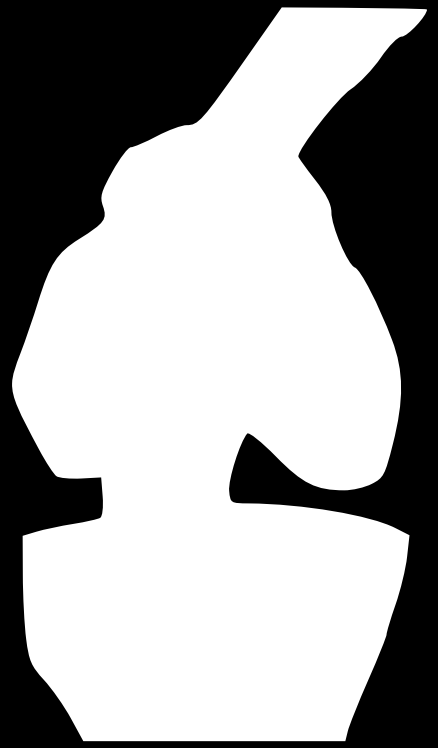
Goal 2: Restore the Natural Knee and Limb Alignments
(Jt Line)

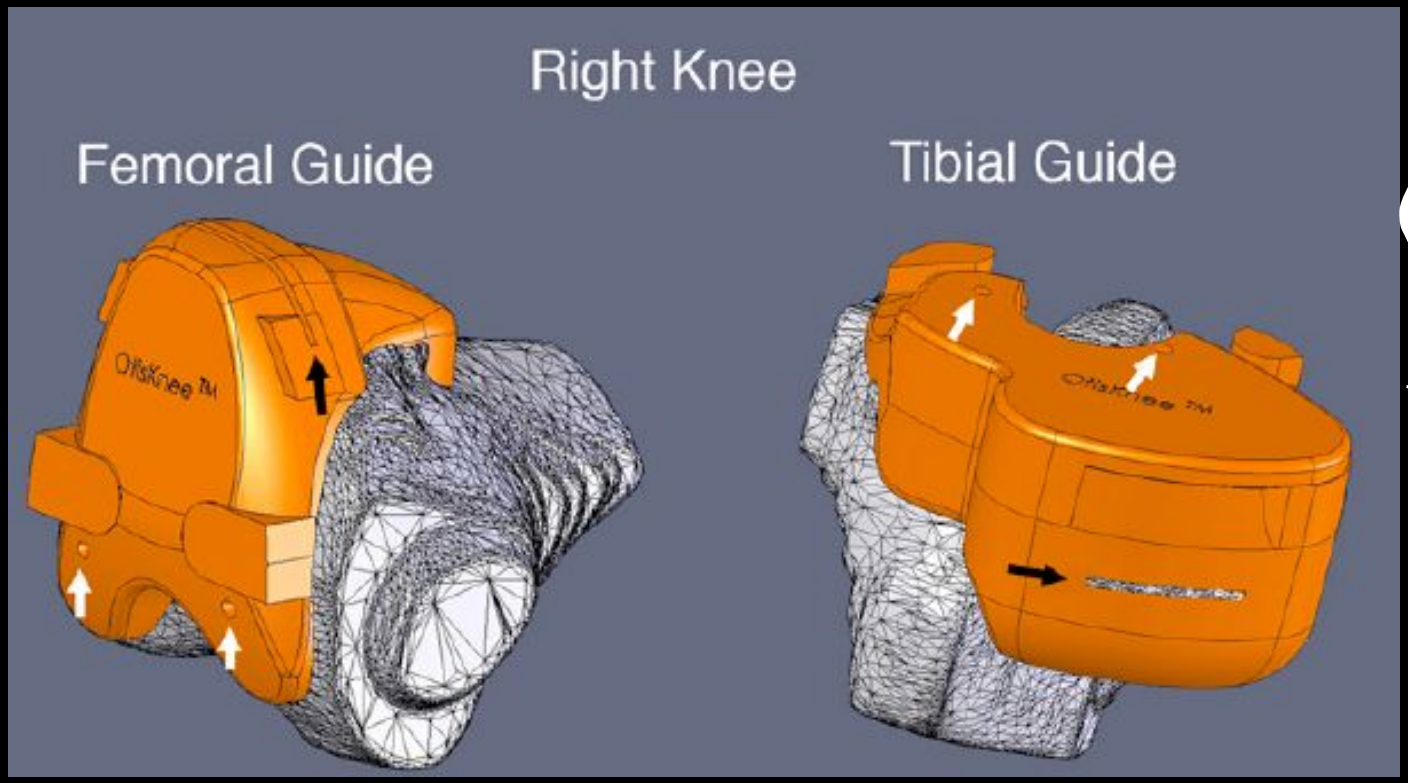
Goal 3: Restore the Natural Laxities of the Knee
(Osteophyte removal-no ligament releases)

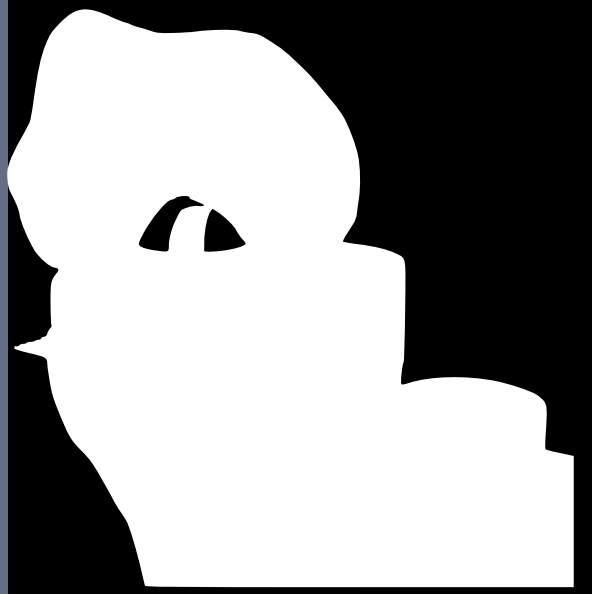
HOW??:Shape-Matching Femoral Component Coaligns Transverse Axes Restoring Motion & Stability **Without Ligament Releases**



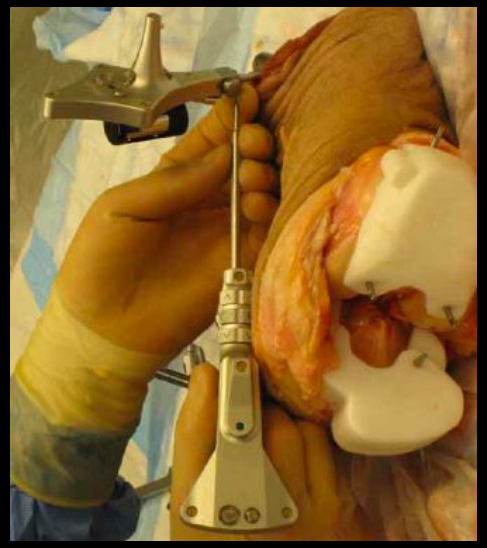
2006
Create 3-D Custom Guides
MRI





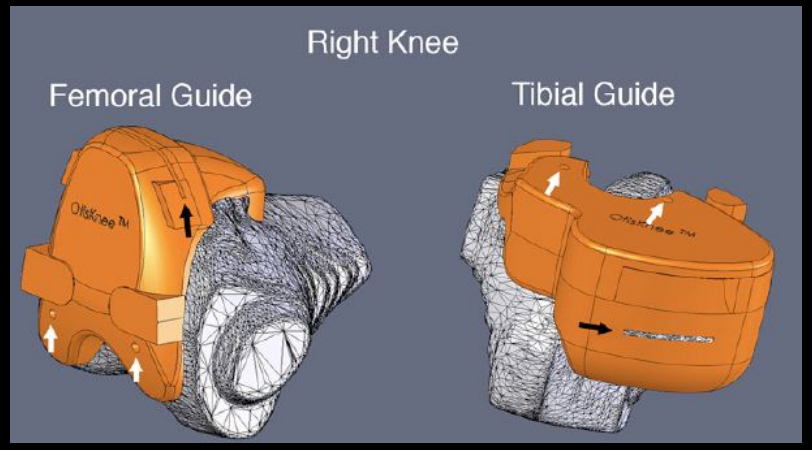


Original Validation- < 1mm

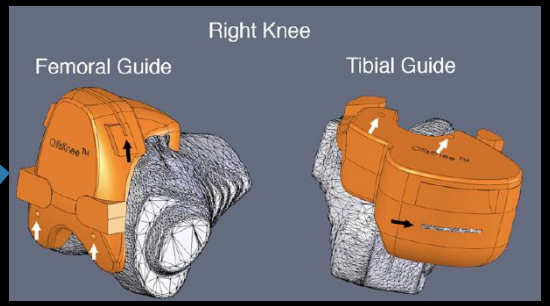


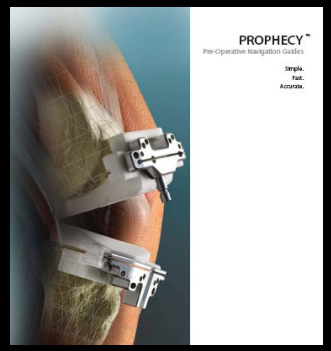
Kinematic History

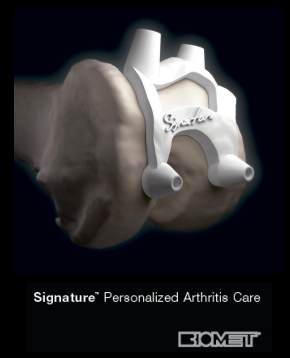
- Kinematically-aligned TKA was first performed in January 2006 with patient-specific guides,
- Over 20,000 were performed in the United States between 2006 and 2009. (>300 surgeons)



Disruptive Innovation

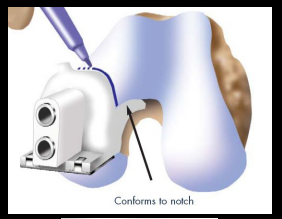






Narrative

- **PSG**
- **Alignment**
- **Outliers**
- **No ligament release**
- **Felt more natural**
- **Faster recovery**



CONFORMIS

2010- 2000 cases

stryker

OtisMed®

ShapeMatch® Technology

KINEMATIC ALIGNMENT REFERENCE GUIDE

Thomas D. Meade, M.D.
Stephen M. Howell, M.D.

P 1-87

OtisMed Challenges Dogma!

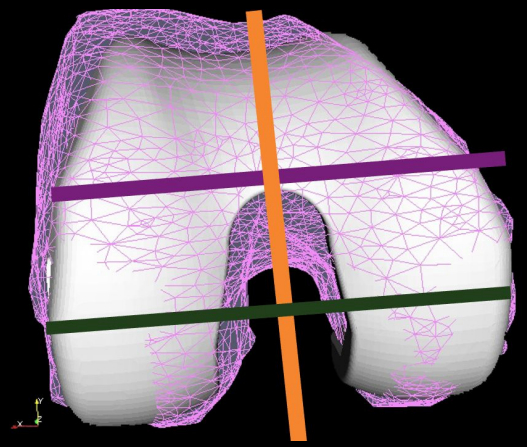
- 0 degree Mechanical axis-Best TKA
- Best F-E axis—not Transepicondylar axis
- Take Computer Navigation– out of the OR
- Anatomic axis based TKA
  - Little/no soft tissue balancing
  - Feels more natural
- References axes- CompNS- ‘more accurate’ misalignment

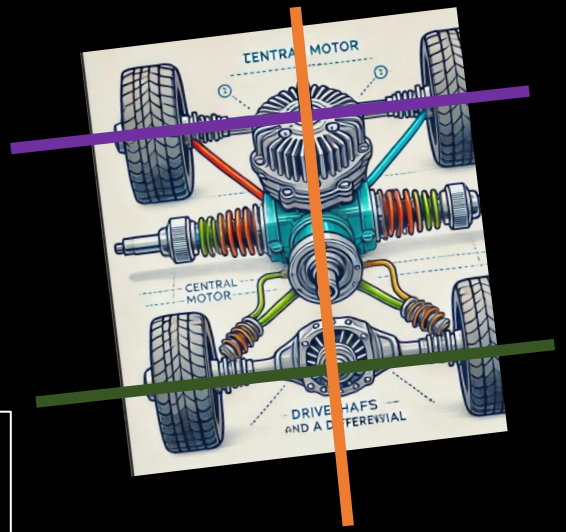
Simple?

$E = mc^2$

PAUSE: Define Alignment

- noun: alignment
  1. arrangement in a straight line, or incorrect or appropriate relative positions—MA TKA
  2. The act of lining parts of a machine. I.e. wheel axle alignment– KA TKA





Straight Line-2-D

Kinematic ‘Alignment’

- Co-aligns 3 Axes of knee rotation
- Either parallel or perpendicular to each other

NO relationship to longitudinal alignment

- EARLY RESPONSE FROM MA TJA TRADITIONAL ELITES
  - RESISTANCE
  - HERECY
  - “SPORTS MEDICINE GUY”- you must be kidding!
  - Group think prevails-
  - DATA will be the proof

Mechanical vs Kinematic

“The difficulty lies not so much in developing new ideas as in escaping from old ones.”

.....John Maynard Keynes- 1883

Many MA's Dr's afflicted Metathesiophobia-Fear of Change

Sad condition

- When things aren't terrible,
  - or just OK --but not great,
  - it's harder to get Dr's to budge

- Eat the same foods they've always eaten
- Buy the same brands they've always bought
- In fact, the longer Dr's do something the more they value it
- Because change often involves uncertainty.
- 80% is just OK!!

- Cognitive Dissonance common in medicine-esp when contradicting traditional elites in established teaching institutions & specialty societies

- “A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.”
  — Max Planck- 1883, Scientific Autobiography and Other Papers

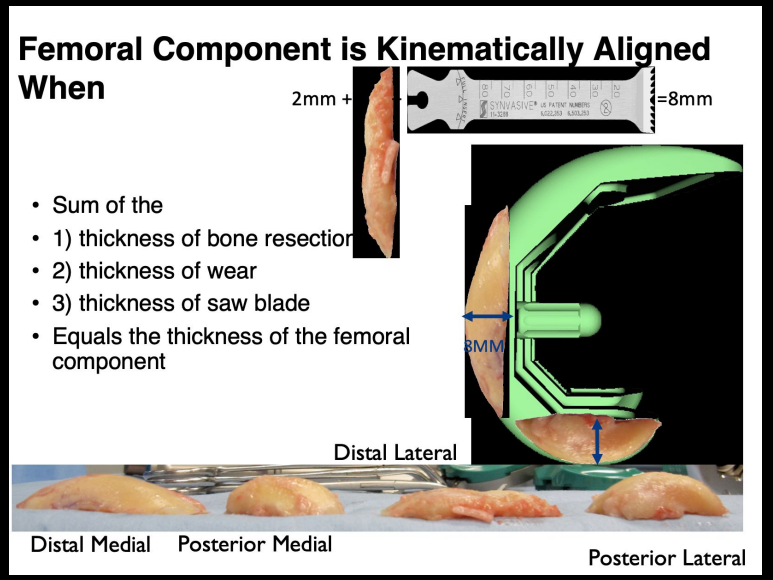
‘Otis’ KA Surgeons

Sept 2009- (‘Panic’ after >20,000 TKA)

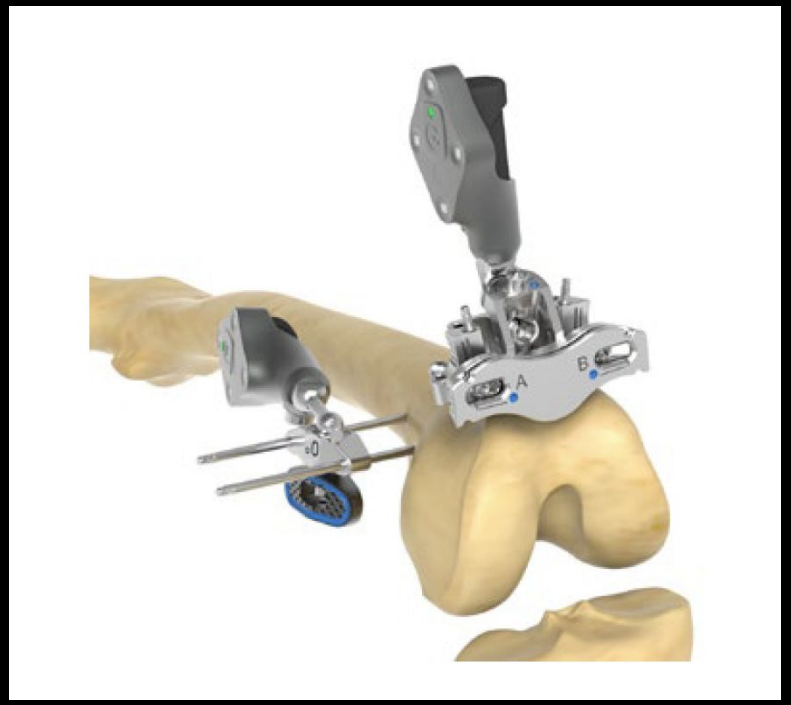
FDA did not approve the use of PSG to perform kinematically aligned TKA

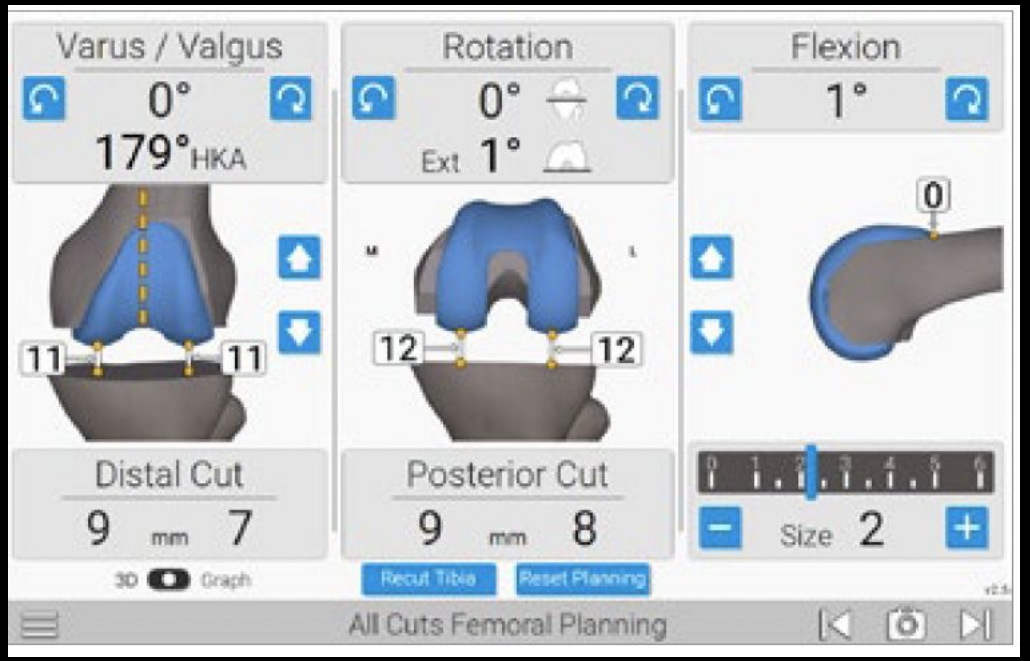
unconventional use of conventional instruments to ‘Custom Position’ Implants -recreate KA results w Otis

then specially designed instruments-



Newton-Exactech GPS Technology





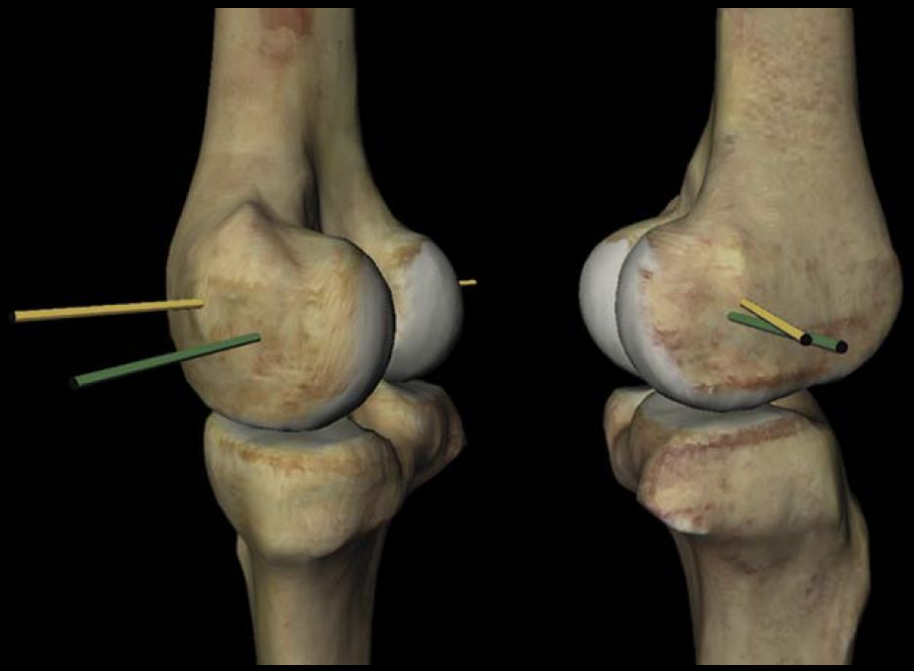
Supportive Articles/Data after 2006

REGULAR AND SPECIAL FEATURES

AN ABJS BEST PAPER 2007

Difference Between the Epicondylar and Cylindrical Axis of the Knee

Donald Eckhoff, MD; Craig Hogan, MD*; Laura DiMatteo, MD*; Mitch Robinson, MD*; and Joel Bach, PhD*,†*



Erroneous Assumption: 5° IM

HOSPITAL FOR SPECIAL SURGERY

Variability in the Distal Femoral Mechanical-Anatomic Angle in Patients Undergoing Primary Total Knee Arthroplasty

Denis Nam, MD; Patrick Maher, BS; Alex Robles, BS; Alexander S. McLawhorn, MD, MBA; David J. Mayman, MD

Hospital for Special Surgery, New York, NY

Financial Disclosure: One author (DJM) has stock options in OrthAlign Inc., and is a consultant for Smith and Nephew

RESULTS

- 28.6% (141 of 493) of patients undergoing TKA had a FMAA value outside of 5° ± 2° (range 2.0° to 9.6°)

CONCLUSIONS

- The distal femoral mechanical-anatomical angle is highly variable in patients undergoing total knee arthroplasty

- Using an intramedullary fixed angle resection guide, without obtaining standing AP hip-to-ankle radiographs to determine a patient's true FMAA, may lead to femoral component malalignment (Fig. 3)

2010

Effect of Postoperative Mechanical Axis Alignment on the Fifteen-Year Survival of Modern, Cemented Total Knee Replacements

By Sebastien Parratte, MD, PhD, Mark W. Pagnano, MD, Robert T. Trousdale, MD, and Daniel J. Berry, MD

Investigation performed at the Mayo Clinic, Rochester, Minnesota

CONCLUSIONS

- MA ± 3° did not improve survival 15 yr
- MA goal 0° ± 3° little practical value predict durability TKA

only published series with both preoperative and postoperative full-length radiographs available for 95% of the patients

The Chitranjan Ranawat Award:

Is neutral mechanical alignment normal for all patients?
The concept of constitutional varus.

2012

Bellemans J,Colyn W, Vandenneucker H, Pellenberg, Belgium.-AAOS 2012

250 asymptomatic adult volunteers between 20 and 27 yo

RESULTS:

32% of men and 17% of women had constitutional varus knees with a natural mechanical alignment of 3° varus or more.

CONCLUSION:

Restoration of mechanical alignment to neutral in these cases may not be desirable

Would be unnatural for them, and require some soft tissue release.

THE BONE & JOINT JOURNAL

A randomised controlled trial of kinematically and mechanically aligned total knee replacements

TWO-YEAR CLINICAL RESULTS

H. G. Dossett,
N. A. Estrada,
G. J. Swartz,
G. W. LeFevre,
B. G. Kwasman

From Phoenix Veterans Affairs Hospital, Arizona, United States

We have previously reported the short-term radiological results of a randomised controlled trial comparing kinematically aligned total knee replacement (TKR) and mechanically aligned TKR, along with early pain and function scores. In this study we report the two-year clinical results from this trial. A total of 88 patients (88 knees) were randomly allocated to undergo either kinematically aligned TKR using patient-specific guides, or mechanically aligned TKR using conventional instruments. They were analysed on an intention-to-treat basis. The patients and the clinical evaluator were blinded to the method of alignment.

At a minimum of two years, all outcomes were better for the kinematically aligned group, as determined by the mean Oxford knee score (40 (15 to 48) *versus* 33 (13 to 48); p = 0.005), the mean Western Ontario McMaster Universities Arthritis Index (WOMAC) (15 (0 to 63) *versus* 26 (0 to 73); p = 0.005), mean combined Knee Society score (160 (93 to 200) *versus* 137 (64 to 200); p= 0.005) and mean flexion of 121° (100 to 150) *versus* 113° (80 to 130) (p = 0.002). The odds ratio of having a pain-free knee at two years with the kinematically aligned technique (Oxford and WOMAC pain scores) was 3.2 (p = 0.020) and 4.9 (p = 0.001), respectively, compared with the mechanically aligned technique. Patients in the kinematically aligned group walked a mean of 50 feet further in hospital prior to discharge compared with the mechanically aligned group (p = 0.044).

In this study, the use of a kinematic alignment technique performed with patient-specific guides provided better pain relief and restored better function and range of movement than the mechanical alignment technique performed with conventional instruments.

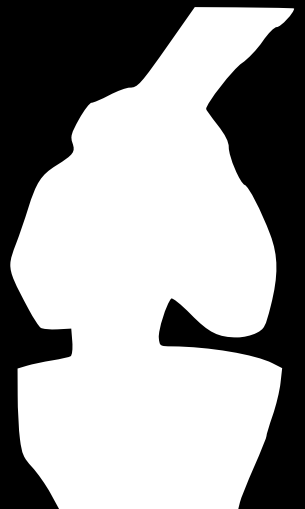
H. G. Dossett, MD, MBA, Chief, Orthopedic Surgery Phoenix Veterans Affairs Health Care System, P.O. Box 27410, Scottsdale, Arizona, 85255, USA.

N. A. Estrada, PhD, MAOM, RN, FNP, Associate Chief

Cite this article: *Bone Joint J* 2014;96-B:907–13.

2014

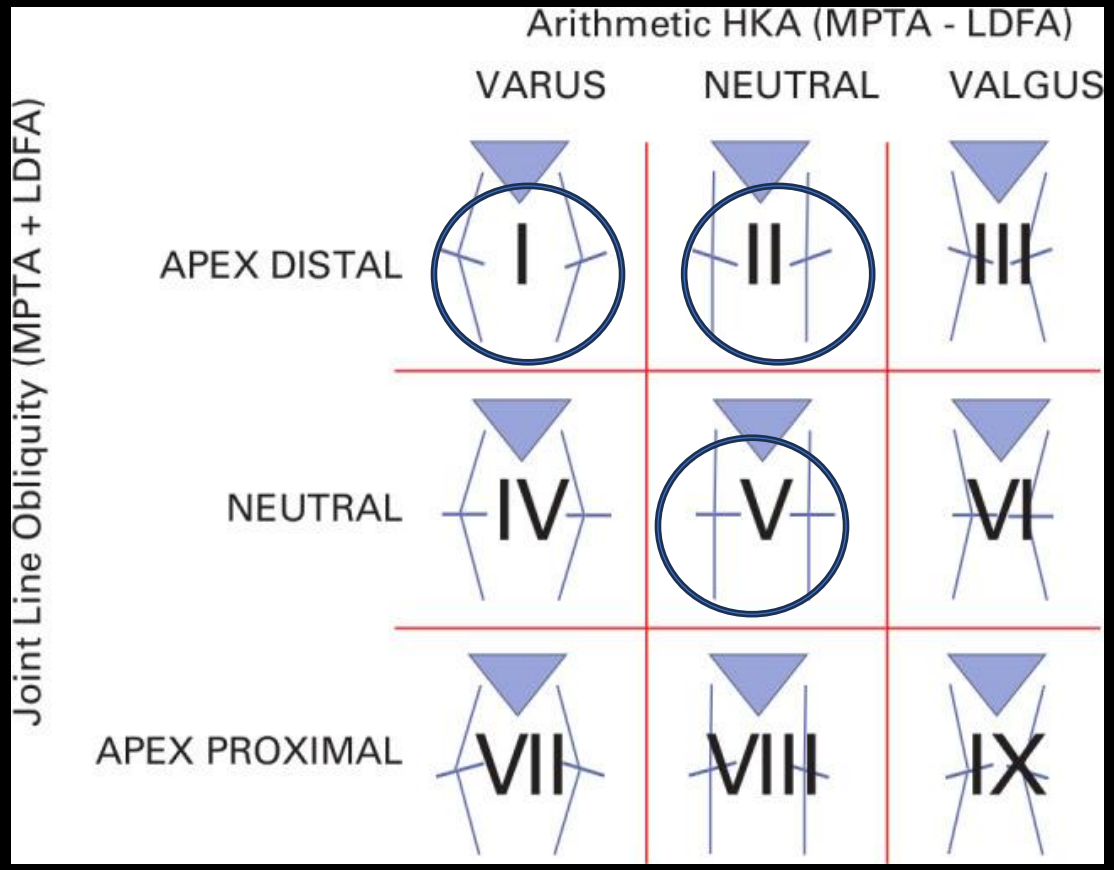
- Better 2yr Outcomes
- Oxford
- WOMAC
- KSS
- ROM
- Pain relief
- Function



2023—Same 15 Yr results
Rev rate same as MA TKA

Coronal Plane Alignment Knee (CPAK)-2021 JBJS n=1000

Type II~35%
Type I~23%
Type V~15%



Results

KA better in all 9
Below greatest

Type I: 100% KA vs 15% MA
Type II: 78% KA vs 46% MA
Type IV: 89% KA vs 0% MA

THE BONE & JOINT JOURNAL

Patient dissatisfaction following total knee replacement

A GROWING CONCERN?

D. Nam,
R. M. Nunley,
R. L. Barrack

From Washington University School of Medicine/Barnes-Jewish Hospital, St. Louis, Missouri, United States

A national, multi-centre study was designed in which a questionnaire quantifying the degree of patient satisfaction and residual symptoms in patients following total knee replacement (TKR) was administered by an independent, blinded third party survey centre. A total of 90% of patients reported satisfaction with the overall functioning of their knee, but 66% felt their knee to be 'normal', with the reported incidence of residual symptoms and functional problems ranging from 33% to 54%. Female patients and patients from low-income households had increased odds of reporting dissatisfaction. Neither the use of contemporary implant designs (gender-specific, high-flex, rotating platform) or custom cutting guides (CCG) with a neutral mechanical axis target improved patient-perceived outcomes. However, use of a CCG to perform a so-called kinematically aligned TKR showed a trend towards more patients reporting their knee to feel 'normal' when compared with a so called mechanically aligned TKR

This data shows a degree of dissatisfaction and residual symptoms following TKR, and that several recent modifications in implant design and surgical technique have not improved the current situation.

Cite this article: ***Bone Joint J*** **2014;96-B(11 Suppl A):96–100.**

2014

MA

Contemporary Implants
Gender TKA
Hi-Flex
Rotating Platform
CCG-MA

Kinematic

CCG—Felt 'Normal"

BTKA: patients prefer KA side

Patients undergoing staged bilateral knee arthroplasty are less aware of their kinematic aligned knee compared to their mechanical knee

Yaron Bar Ziv [a], Ilan Small [a], Tomer Keidan [b,*], Eran Beit Ner [a], Gabriel Agar [a], Noam Shohat [a]

[a] *Assaf Harofeh Medical Center, Department of Orthopedic Surgery and Rehabilitation. Rishon Letzion, Israel*
[b] *University of Florida College of Medicine – UF Health Shands. Gainesville, Florida, USA*

Outcomes in Patients with a Calipered Kinematically Aligned TKA That Already Had a Contralateral Mechanically Aligned TKA

Trevor J. Shelton, MD, MS[1] Manpreet Gill, PA-C, MS[2] Gurbir Athwal, BS[3] Stephen M. Howell, MD[4]
Maury L. Hull, PhD[5]

Contents lists available at ScienceDirect

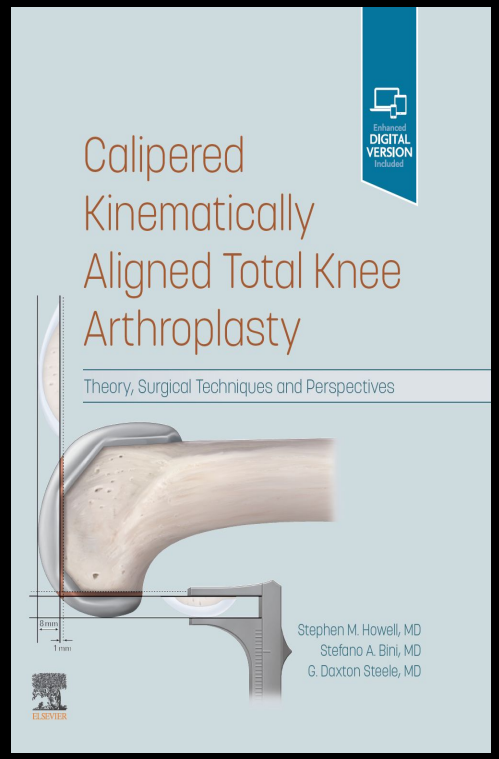
The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Implant Survival and Function Ten Years After Kinematically Aligned Total Knee Arthroplasty

Stephen M. Howell, MD [a], Trevor J. Shelton, MD, MS [b,*], Maury L. Hull, PhD [a,b,c]

- Howell-10 yr KA -2016
  - Better pain, flexion, function, normal



1. Almaawi AM, Hutt JRB, Masse V, Lavigne M, Vendittoli PA (2017) The impact of mechanical and restricted kinematic alignment on knee anatomy in total knee arthroplasty. J Arthroplast 32(7):2133–2140
2. Blakeney W, Clement J, Desmeules F, Hagemeister N, Riviere C, Vendittoli PA (2018) Kinematic alignment in total knee arthroplasty better reproduces normal gait than mechanical alignment. Knee Surg Sports Traumatol Arthrosc. https://doi.org/10.1007/s00167-018-5174-1
3. Gu Y, Roth JD, Howell SM, Hull ML (2014) How frequently do four methods for mechanically aligning a total knee arthroplasty cause collateral ligament imbalance and change alignment from normal in white patients? AAOS exhibit selection. J Bone Joint Surg Am 96(12):e101
4. Hess S, Moser LB, Amsler F, Behrend H, Hirschmann MT (2019) Highly variable coronal tibial and femoral alignment in osteoarthritic knees: a systematic review. Knee Surg Sports Traumatol Arthrosc. https://doi.org/10.1007/s00167-019-05506-2
5. Hirschmann MT, Hess S, Behrend H, Amsler F, Leclercq V, Moser LB (2019) Phenotyping of hip-knee-ankle angle in young non-osteoarthritic knees provides better understanding of native alignment variability. Knee Surg Sports Traumatol Arthrosc. https://doi.org/10.1007/s00167-019-05507-1
6. Hirschmann MT, Moser LB, Amsler F, Behrend H, Leclercq V, Hess S (2019) Phenotyping the knee in young non-osteoarthritic knees shows a wide distribution of femoral and tibial coronal alignment. Knee Surg Sports Traumatol Arthrosc. https://doi.org/10.1007/s00167-019-05508-0
7. Hirschmann MT, Moser LB, Amsler F, Behrend H, Leclerq V, Hess S (2019) Functional knee phenotypes: a novel classification for phenotyping the coronal lower limb alignment based on the native alignment in young non-osteoarthritic patients. Knee Surg Sports Traumatol Arthrosc. https://doi.org/10.1007/s00167-019-05509-z

8. Howell SM, Howell SJ, Kuz… Does a kinematically aligned t… tion without failure regardless… Relat Res 471(3):1000–1007
9. Howell SM, Shelton TJ, Hul… function 10 Years after kinen… plasty. J Arthroplasty 33(12):…
10. Hutt JR, LeBlanc MA, Masse… Kinematic TKA using naviga… results. Orthop Traumatol Sur…
11. Lee YS, Howell SM, Won … Teo SH (2017) Kinematic ali… mechanical alignment in total … Traumatol Arthrosc 25(11):34…
12. Moser LB, Hess S, Amsler F, … Native non-osteoarthritic kne… alignment: a systematic revi… Arthrosc. https://doi.org/10.1…
13. Nedopil AJ, Howell SM, Hu… are associated with tibial com… aligned total knee arthroplasty…
14. Nedopil AJ, Singh AK, Howe… pered kinematically aligned T… metry of the lower limb and … 33(2):398–406
15. Niki Y, Nagura T, Nagai K, K… ematically aligned total knee a… moment more than mechanic… Knee Surg Sports Traumatol Arthrosc 26(6):1629–1635
16. Riley J, Roth JD, Howell SM, Hull ML (2018) Increases in tibial force imbalance but not changes in tibiofemoral laxities are caused by varus-valgus malalignment of the femoral component in kinematically aligned TKA. Knee Surg Sports Traumatol Arthrosc 26(11):3238–3248
17. Riley J, Roth JD, Howell SM, Hull ML (2018) Internal–external malalignment of the femoral component in kinematically aligned

…imbalance but does … Knee Surg Sports …
…enditoli PA, Cobb J, … knee arthroplasty: a … s 103(7):1047–1056 …ematically aligned …rces, differences in … ormal tibial contact … g Sports Traumatol …
… there a force target … after kinematically … :1200–1207 …tal knee arthroplasty … is greater than the …055/s-0038-1675421 …IL (2017) Do varus …edial or lateral com… …ter a kinematically …oint line alignment … plasty. Bone Joint J …
…msler F, Huegli RW, …eads to higher knee … preoperatively non… …using 3D-CT. Knee … -1609

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ten Flaws of Systematic Mechanical Alignment Total Knee Arthroplasty

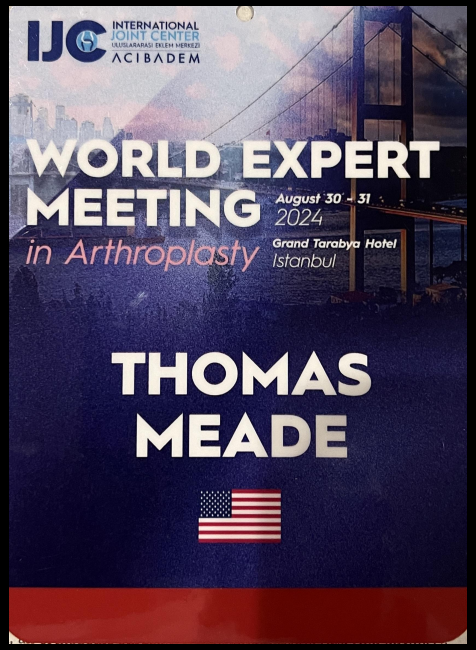
Gautier Beckers, MD [a,b] · R. Michael Meneghini, MD [c,d] · Michael T. Hirschmann, MD [b,e] · Lazaros Kostretzis, MD [f] · Marc-Olivier Kiss, MD, MSc [a,b,g] · Pascal-André Vendittoli, MD, MSc [a,b,g]

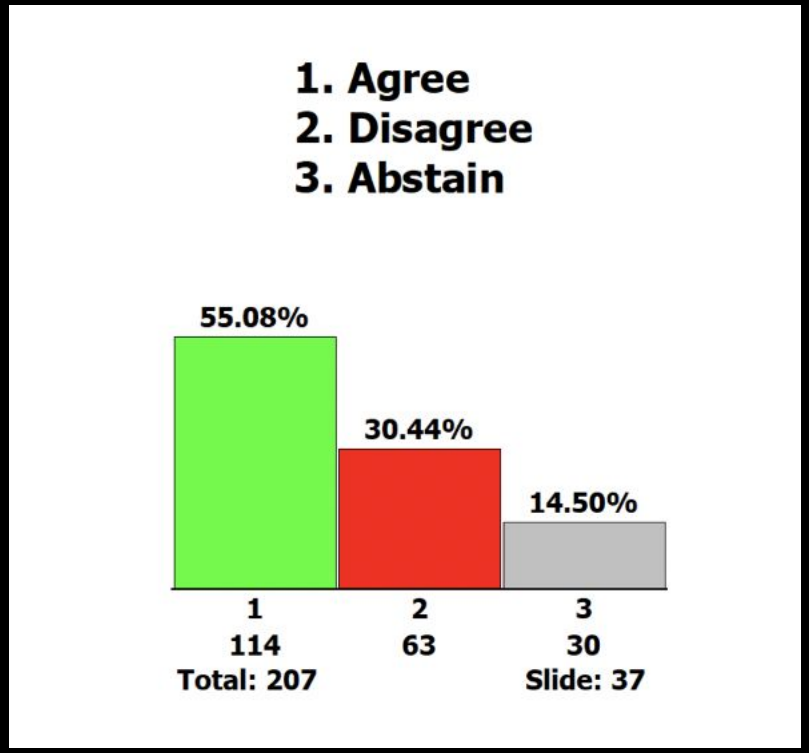
•**Question:**

Is there a difference in the outcome of primary total knee arthroplasty performed using kinematic versus mechanical alignment?

•

- **Response/Recommendation: Kinematic alignment appears to result in improved patient-reported outcome measurements (PROMs) in the early recovery period** and equal mid and longer-term follow-ups. Nonetheless, kinematic alignment also achieves a more natural joint line position and potentially better soft-tissue balance.





All truth passes through three stages.

First, it is ridiculed.

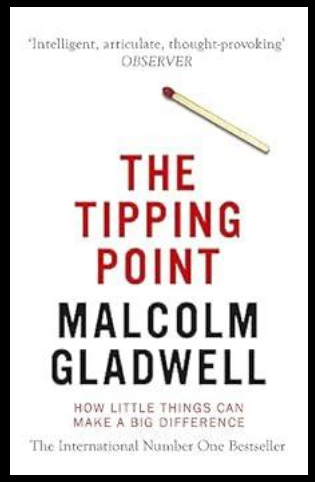
Second, it is violently opposed.

Third, it is accepted as being self-evident.

Arthur Schopenhauer
German philosopher (1788 - 1860)

Personalized Alignment Techniques

- Mechanical Alignment- Gold Standard >5 decades
- Anatomic Alignment (Krakow & Hungerford)
- Kinematic Alignment (Howell 2006)



  - Restrictive KA
  - Inverse KA
  - Functional Alignment

KA TKA 2006-2024 = 18 yrs!!!!

Medical News & Perspectives

April 5, 2023

It Takes an Average of 17 Years for Evidence to Change Practice—the Burgeoning Field of Implementation Science Seeks to Speed Things Up

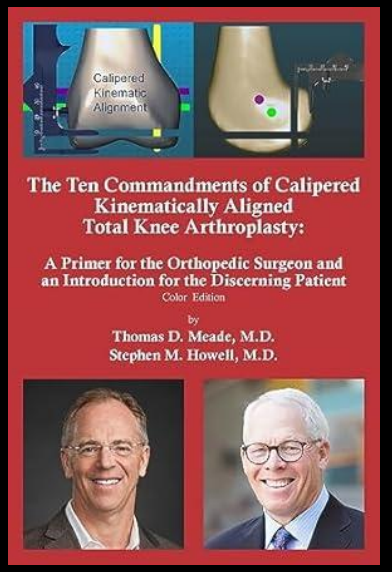
Rita Rubin, MA

Article Information

JAMA. 2023;329(16):1333-1336. doi:10.1001/jama.2023.4387

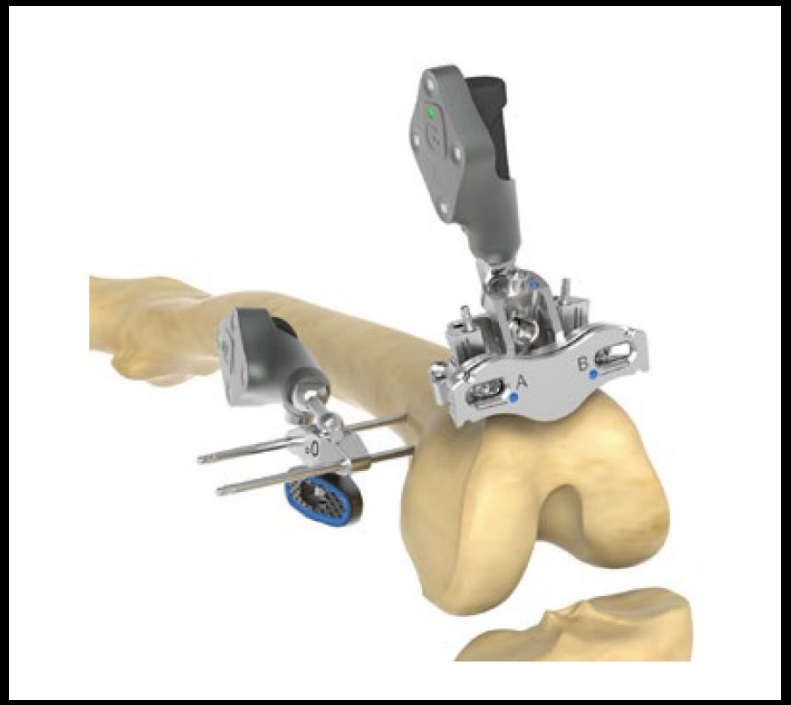
JAMA 2023

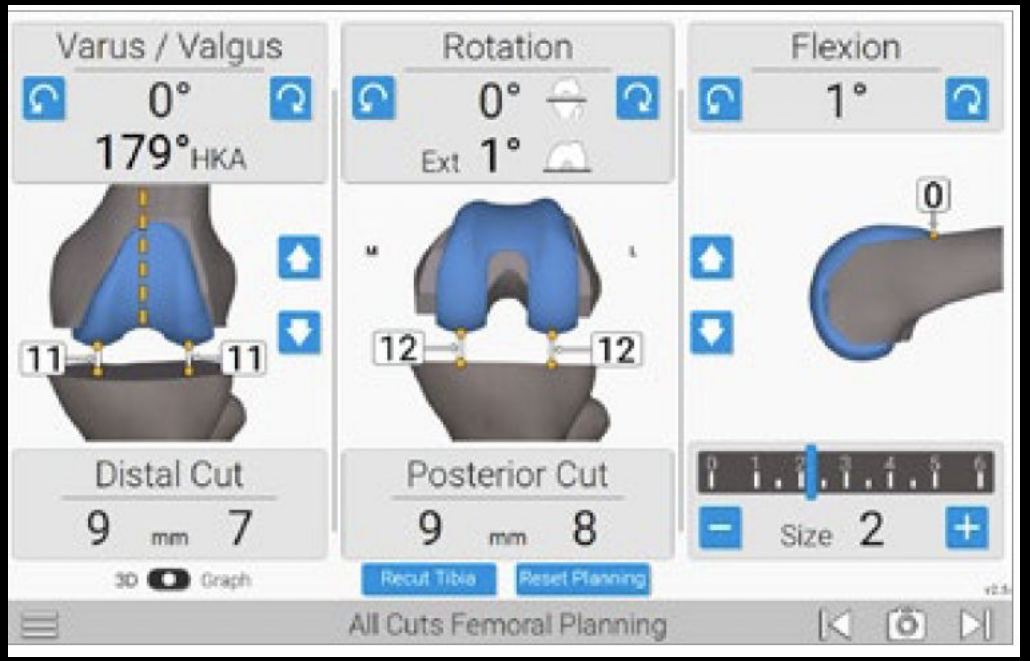
Most important Things I've Learned



1. Once go Kinamatic- Never go back
2. MA Dr's- very proud & sensitive species
3. Seeing is believing- value of site visit
4. Sports Medicine Dr's get it sooner (Ligament preservationists)
5. Experience pre-dates published results- trust your gut
6. Baby steps important
7. KA has a negligible risk of implant failure even with a 10º varus tibial resection
8. KA resurfaces the pre-arthritic knee without releasing ligaments
9. Measure bone resections with a caliper to verify
10. International Consensus on superior KA PROM

Newton-Exactech GPS Technology






Thank You!