A new approach to Total Joint Replacement

Abhijit Manaswi Board certified Fellowship trained Total Joint Surgeon

MD, MS, FCPS, DNB, MNAMS, FRCS (Edinburgh)

Director, Joint Replacement Center Heart of Florida Regional Medical Center Davenport, Florida



• I HAVE NO CONFLICT OF INTEREST OR • ANY FINANCIAL DISCLOSURES

Presentation Overview

Here is what we will be discussing KNEES

- Osteoarthritis of the Knee
- Traditional Treatment Options
 - Non-surgical
 - Surgical
- Pitfalls of Traditional Treatment Options
- New Robotic-Arm Assisted Treatment Option
 HIPS
 - Degenerative Joint Disease of the Hip
 - Pitfalls of Traditional Treatment Options
 - New Robotic-Arm Assisted Treatment Option

Osteoarthritis of the Knee

Signs & Symptoms

- Pain
 - Standing or walking short distances
 - Climbing up and down stairs
 - Getting in and out of chairs
- Stiffness
 - Initiating activities from a sitting position
 - After getting out of bed
- Swelling
- A Grating Sensation or Crunching Feeling
- Decreased Range of Motion (Ability to bend knee fully)
- Instability
- Reduced Activity

Osteoarthritis (OA)

- A degenerative bone disease that causes cartilage found on healthy joints to break down, removing the buffer between bones.
- 15 million Americans suffer with OA of the knee.¹
- 46% of people will develop knee OA over their lifetime.²
- The 55+ age group, peak knee pain candidates, will grow 3 times the average rate of the U.S. Population, reaching 96 million by 2020.³



1 AAOS

2. Arthritis Care & Research, September 2008 . Thurston Arthritis Research Center, University of North Carolina-based Johnston County Osteoarthritis Project.

3. U.S. Census Bureau

Osteoarthritis Disease Progression

Progression of knee joint disease

- Early-stage: Mild disease
 - Sports related injuries
 - Minor defects/ loss of cartilage

• Mid-stage: Moderate disease

- Increased pain
- Reduced mobility
- Changes to lifestyle/sports activiti
- Partial knee disease: one or two compartments

• Late-stage: Severe disease

- Leading cause of disability
- Severe pain
- Walking, stair climbing challenging
- Total knee disease







Osteoarthritis

Knee Anatomy



Osteoarthritis

Reduced Joint Space (Bone-on-bone)



Normal



Reduced Joint Space

Osteoarthritis

Reduced Joint Space (Bone-on-bone)



Osteoarthritis *causes of bone-on-bone knee pain?*

Old Sports Injury (tears or fractures)



Tear in

meniscus

Meniscus repaired

with sutures

HH



Osteoarthritis causes of bone-on-bone knee pain?

Long-term Impact Activities (work or sports)



Osteoarthritis causes of bone-on-bone knee pain?

Obesity



<u>Normal</u> joint force

Joint force due to obesity

- Weight loss
- Non-steroidal anti-inflammatory drugs
- Injections (Cortisone & Visco supplements)
- Change in activities to include low-impact exercising (i.e. biking, swimming etc)



Arthroscopic Surgery

- Cleans or trims damaged cartilage (debridement)
- Variable benefits may be just for diagnostic purposes



Total Knee Replacement is considered the Gold Standard

- 600,000 performed annually in U.S.
- Proven long term survivorship 90% out 15 years
- Can correct large deformities



Total Knee Replacement has limitations

- Highly invasive surgery
- Requires months of extensive rehabilitation
- Addresses late stage osteoarthritis (OA)
- Removes healthy cartilage and tissue
- Only 82% of 10,000 patients were satisfied with their outcome³

¹Phase I Final Report (Part C): Effects of Advanced Medical Technologies – Musculoskeletal Diseases Medical Technology Assessment Working Group: Assessing the Impact of Medical Technology Innovations on Human Capital Duke University Center for Demographic Studies, Prepared for the Institute for Medical Technology Innovation, January 31, 2006
² Linoard JBJS 2006

³ National Joint Registry England/Wales

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Unicondylar Knee Replacement (UKA)

(also known as Partial Knee Replacement)

- Less than 50,000 partial knee procedures in the United States in 2007
- ACL and PCL remain intact
- Traditionally performed with manual instruments





Why traditional Uni Knees have not been as common or successful?

- Narrow Indications: Knee Cap disease not addressed
- Outcomes widely variable: many leading to early failure
- Technically more demanding than TKA
- Poor Ligament Balancing
- Overstuffing causing progressive lateral wear
- Mal-Alignment of Implants
- Deep tibial resections causing difficult revisions with augments



Traditional Treatment Gap



MAKOplasty® May Fill the Gap



MAKOplasty[®] is Enabled by the RIO[®] Robotic Arm Interactive Orthopedic System



Pre-operative Planning



Exposure



Data Gathering



Intra-operative Registration



Intra-operative Adjustments – Knee Balancing



Intra-operative Femoral Resurfacing



Tibial Preparation



Femoral Preparation



Intra-operative Tibial Resurfacing



MAKOplasty® Radiographic Outcomes



PRE-OP/POST-OP



MAKOplasty[®] Knee Potential Patient Value

- Performed through a smaller incision than that required for traditional total knee replacement surgery.
- Only the arthritic portion of the knee is removed, preserving healthy bone and tissue.
- Implants are optimally positioned in the knee joint to allow the knee to move smoothly again.
 - Improved surgical outcomes
 - Less implant wear and loosening
 - Bone sparing
 - Smaller incision, Less invasive
 - Less scarring
 - Reduced blood loss
 - Minimal hospitalization
 - Rapid recovery
 - Ligaments remain in tact for a more natural feeling knee
 - * Individual results may vary. There are risks associated with any knee surgical procedure, including MAKOplasty[®]. Your physician can explain these risks and help determine if MAKOplasty[®] is right for you.

Clinical Study – Medial Uni 2-yr Outcome

0.4% revision rate

 201 patients (224 knees) from 4 surgeons were enrolled in the study, with follow up at a minimum of 2 years (Average follow up = 32 ± 5 months)



- 1. ZUK: Zimmer[®] Unicompartmental High Flex Knee
- •
- Oxford[®] is a registered trademark of BioMet UK Ltd.

Clinical Study – Medial Uni Satisfaction

2-yr outcome satisfaction

- 89% of Robotic Arm Assisted UKA patients were "Satisfied" or "Very Satisfied" (200/244)
- 75% of TKA patients were "Satisfied" or "Very Satisfied"¹



1. Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. Clin Orthop Relat Res. 2006;452: 35-43.

OrthoMap® Express Knee Navigation – Computer Assisted


OrthoMap Express Knee – Points of Interest

- Less invasive: no need for tracker pins in the shafts of the femur or tibia
- A "simplified" navigation solution: navigate distal femur and proximal tibia cuts; cut-check-only feature included
- Open platform: works with any implant System

OrthoMap Express Knee – Points of Interest



Express Knee – The Overall Procedure

- Incision all standard techniques for exposing the knee joint may be applied
- Prepare femur
- Attach fixation plate to distal femur
- Register femur
- Navigate and resect distal femur
- Distal femur cut verification
- Option to align femoral rotation (requires additional registration points)
- Prepare tibia
- Attach fixation plate to proximal tibia
- Register tibia
- Navigate and resect proximal tibia
- Proximal tibia cut verification
- Proceed with conventional TKA

Express Knee – The Overall Procedure

User Preferences			Navigationadmin
General		Famu	Tibia
🗹 Show usage info screens		Weigate distal cut	Verify proximal cut
Prepare femur first		Determine femoral rotation	
🕑 Prepare tibia first		Determine AP distance	
Preferred Implant Position			
	Set:	Default	
	Femura	Q [≠] fasion	measured from the
		& mm resection level	there promineral
		0 ^a slope	resourced incentive
		8 mm resection level	congernent highed

• Tracker attachment on articular surface with four 1/8" pins

 Mount femoral tracker to fixation plate

Femur Preparation



Femur Registration

Requires six landmark registration points

- Hip in Flexion
- Hip Center
- Knee Center
- Femoral AP Axis
- Medial Condyle
- Lateral Condyle



Femur Registration



• Attach Dedicated Mini Jig to the fixation plate. The cutting plane is tracked using the blue tracker

Resect Distal Femur



Resect Distal Femur

• Distal femoral cutting plane is viewed on the virtual model created by the software

 Adjustments to varus/valgus, flexion/extension and resection depth are made in real time



Resect Distal Femur



Distal Femur Cut Verification

• Verification of cut via reregistration of the mechanical axis

 Plane probe is pinned in the center of the femur with neutral rotation using two 1/8" headless pins

 Range of motion re-finds the femoral head center



Distal Femur Cut Verification



Tibia Preparation

- Fixation plate pinned to the tibial plateau with four 1/8" pins
- Mount tibial tracker to fixation plate

Tibia Preparation



Tibia Registration

- Requires six landmark registration points
- Tibia Center
- Tibial AP Axis
- Medial Compartment
- Lateral Compartment
- Medial Malleolus
- Lateral Malleolus



Tibia Registration



• Attach Dedicated Mini Jig to the fixation plate. The cutting plane is tracked using the green tracker

Resect Proximal Tibia



Resect Proximal Tibia

• Proximal tibia cutting plane is viewed on the virtual model created by the software

 Adjustments to varus/valgus, slope and resection depth are made in real time



Resect Proximal Tibia



Proximal Tibia Cut Verification

Plane probe is pinned in the center of the tibia with neutral rotation using two 1/8" headless pins

 Redigitization of malleoli calculates the tibial mechanical axis

 Display of cut plane relativeto the mechanical axis



Proximal Tibia Cut Verification



Proximal Tibia Cut Verification



Register Femur



Main Menu

Back.

Attach green tracker to femur. Flex hip at any angle and press button to record position.

Register Tibia



Attach blue tracker to tibia. Digitize the middle of the interspinous sulcus anteriorly, near the anterior aspect of the ACL attachment.



Challenges & Revision Total Knee Replacement !

Alignment challenges!



28⁰ valgus deformity!



Normal alignment!



Pre and Post-op





Prior fracture and mal-union?





Computer Assisted TKA





Fracture/ non-union


Fracture repair



Computer assisted TKA





Knee instability !



Revised to a constrained implant!







Large defects in the bone ?







Porous metal cones and sleeves!



Failed Uni !



Medial Hemi-augments!



Failed Uni with bone loss/osteolysis







Medial Hemi-augment



Failed Total Knee ?







Hinged Total Knee !



Severe deformity ?



Bone loss !!





Porous metal sleeve & hinge !





Extensive fracture with hardware ?





Computer Assisted TKA!





Extensive bone loss ?





Metal femur!





Metal femur!



Total Hip Replacement!

Signs & Symptoms?

- Pain while putting weight on the affected hip
- Limping to lessen the weight-bearing pressure on the affected hip
- Pain that may radiate to the groin, lower back, or down the thigh to the knee
- Hip pain or stiffness during walking or other impact activities
- Failure to respond to non-surgical treatments or nomsteroidal anti-inflammatory medication



Rheumatoid Arthritis (RA)

An inflammatory arthritis of the joints.



Post-Traumatic Injury (severe fracture or dislocation)





Avascular Necrosis (AVN)

 Condition where the "ball" of the femoral head has lost a healthy supply of blood flow, causing the bone to die and the femoral head to become misshapen.



Hip Dysplasia

• Condition in which bones around the hip did not form properly, which may cause misalignment of the hip joint.



Osteoarthritis (OA)

- A degenerative bone disease that causes cartilage found on healthy joints to break down, removing the buffer between bones.
- Osteoarthritis (OA) is the most common cause of hip replacement surgery.¹
- 14.3% of older adults report significant hip pain²
- 50% growth in hip OA expected by 2035, from the 3 million currently suffer with hip OA



^{1.} AAOS website, retrieved September 2011

^{2.} Colleen Christmas, MD; Carlos J. Crespo, DRPH; Shawn C. Frankowiak; Joan M. Bathon, MD; Susan J. Bartlett, PhD; Ross E. Andersen, PhD. "How Common Is Hip Pain among older adults? Journal of Family Practices, April 2002, Vol 51, No4.

Osteoarthritis

Reduced Joint Space (Bone-on-bone)



Osteoarthritis *causes of bone-on-bone pain?*

Obesity



<u>Normal</u> joint force

Joint force due to obesity

Complications in Total Hip Arthroplasty

Short Term

- Dislocation is the leading short term complication for total hip Replacements² -- National average is around 4%²
- Leg Length Discrepancy

Long Term

- Implant loosening caused by vertical cups and polyethylene wear⁴
- Accelerated Wear

•2. Phillips CB, Barrett J, Losina E, et al. Incidence rates of dislocation, pulmonary embolism, and deep infection during the first six months after elective Total Hip Replacement. J Bone Joint Surg Am. 2003;85:2026.

Importance of Acetabular Cup Orientation

Improper acetabular orientation is one of several factors that have been shown to contribute to⁶

- Increased dislocation rates
- Limb-length discrepancies
- Altered hip biomechanics
- Component impingement
- Bearing surface wear
- Pelvic osteolysis
- Long-term revisions



Clinical Study – Hip Cup Placement

MGH Manual Cup Positioning resulted in 47% inside safe zone¹



MAKOplasty® resulted in 84% inside safe zone



1. The John Charnley Award: Risk factors for cup malpositioning: Quality improvement through a joint registry at a tertiary hospital.
Clin Orthop Relat Res. 2011 Feb;469(2):319-29.

THA Implant Alignment Options



Robotic Arm Assisted MAKOplasty® Hip

Consistently Reproducible Precision

- Patient-specific 3-D pre-op and intra-op planning
- Guided femoral neck resection
- Robotic arm assisted and controlled acetabular reaming
- Robotic arm assisted and controlled cup placement
- Leg length and offset measurement intra-op

Surgeon operates

robotic arm within the

RIO® Enables Consistently Reproducible Precision

Pre-operative Planning


RIO[®] Enables Consistently Reproducible Precision

Intra-operative Reaming

















Acetabular Reaming



Acetabular Reaming



RIO[®] Enables Consistently Reproducible Precision

Intra-operative Impaction



Cup Impaction



Cup Impaction



RIO[®] Enables Consistently Reproducible Precision

Post-operative X-ray



MAKOplasty® Hip Potential Patient Value

- Reduced risk of leg length discrepancy
- Decreased risk of dislocation
- Improved soft tissue tension of the hip
- Improved post-operative range of motion
 - Improved implant survivorship
 - Rapid pain relief and return to daily activities



Individual results may vary. There are risks associated with any hip surgical procedure, including MAKOplasty[®]. A doctor can explain these risks and help patients determine if MAKOplasty[®] is right for them.

MAKOplasty® Experience World-Wide

- First Procedure Performed June 2006
- Over 23,000 Procedures Performed
- Over 156 Accounts

Revision Total Hip Replacement Surgery!

Femur Bone loss!





Finished Product!



Acetabular Bone loss!



Careful planning: 3D CT pelvis model





Custom Tri-flanged cup !







Final reconstruction!





Severe bone loss!



Broken stem with bone loss!





Bone graft and multiple screws!





Peri-prosthetic fracture!





Circlage and longer stem!







Recurrent dislocation!





Cage for acetabular bone loss!



Acetabular erosion!





Head autograft with multiple screws!





Thank You!