



Advancements in Knee Replacement and Enabling Technologies

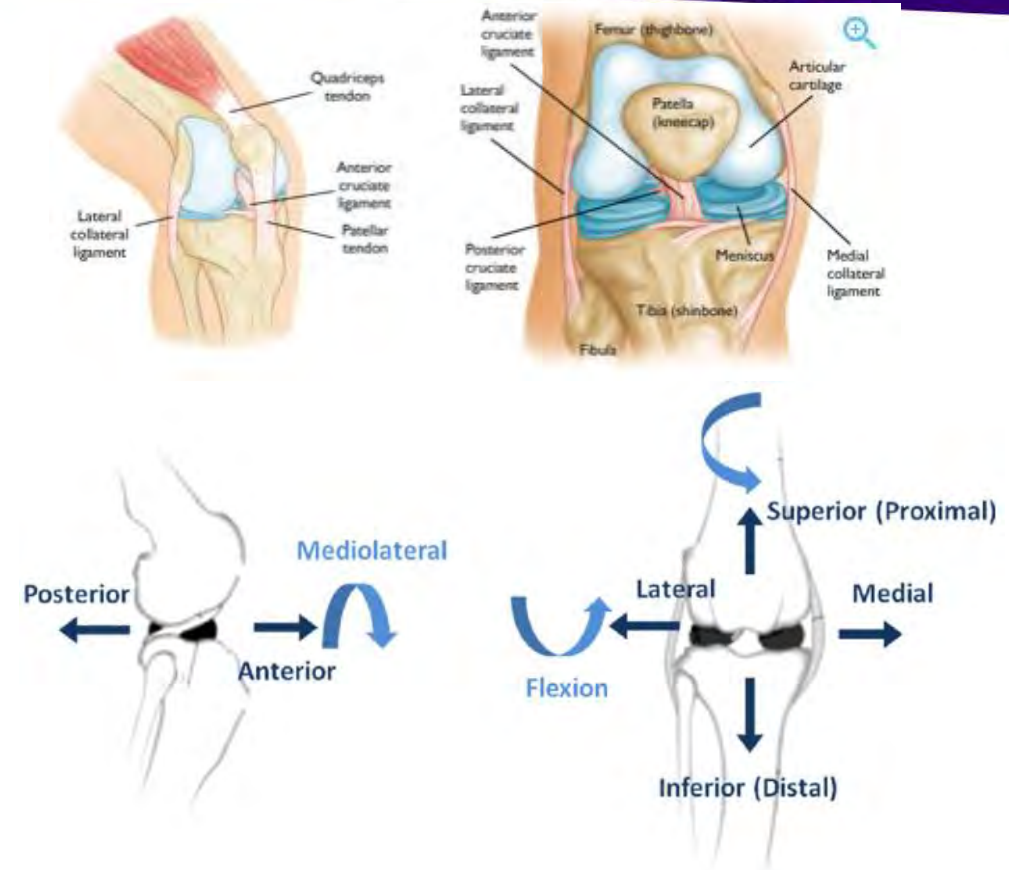
James B. Chen M.D.
Adult Reconstruction and Joint Replacement Surgeon

Objective

- To gain a better understanding of knee replacement surgery and the advancements being made in the field.
- <https://hipknee.aahks.org/total-knee-replacement/>
- <https://www.orthoinfo.org>

The Knee

- Complex joint!
- Motion
 - Bends (flex/extends)
 - Rotates
 - Side to side translation
 - Side to side bend (varus/valgus)
 - Compression and distraction



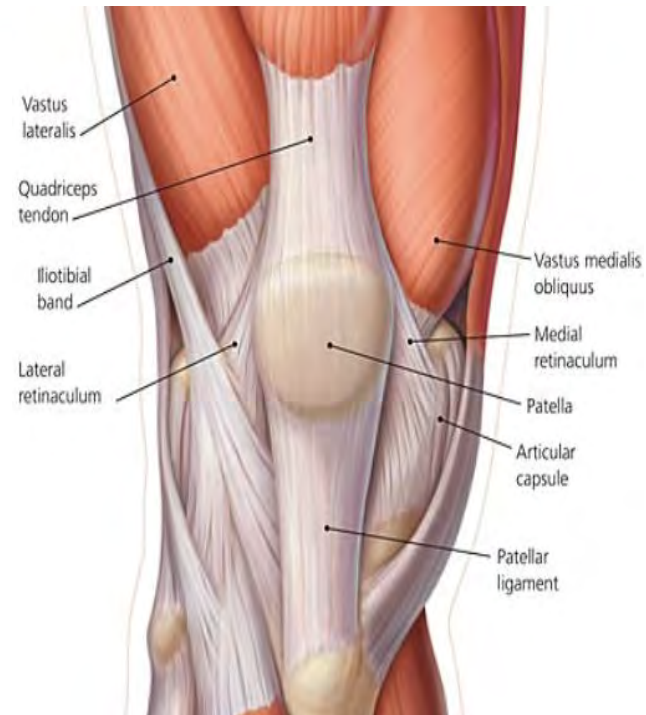
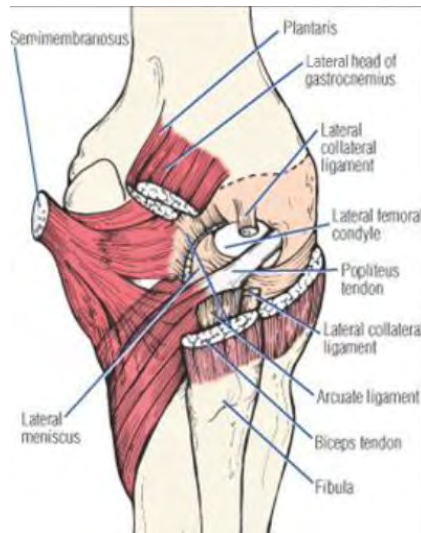
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<https://www.orthobullets.com/recon/9065/knee-biomechanics>

[Smart Knee Brace Design with Parallel Coupled Compliant Plate \(PCCP\) Mechanism and Pennate Elastic Band \(PEB\) Spring](#)

The Knee

- Complex joint!
- Muscular and ligamentous Anatomy
 - Each contribute to STABILITY, STRENGTH, and FLEXIBILITY

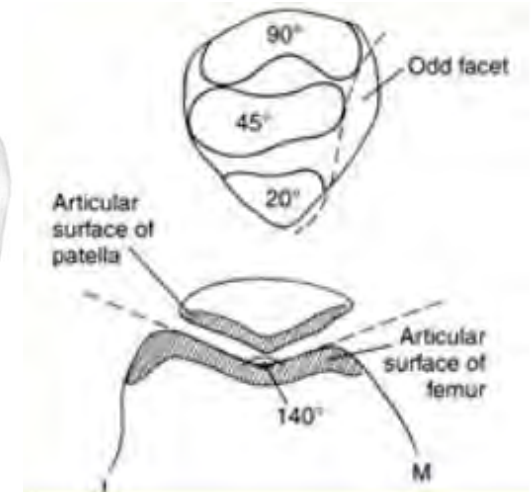
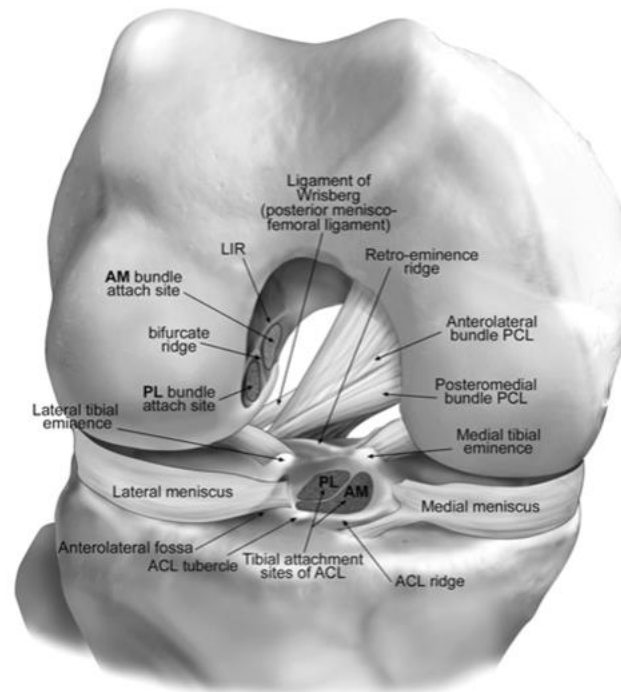


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<https://www.orthobullets.com/recon/9065/knee-biomechanics>

The Knee

- Complex joint!
- Bony Anatomy
 - Patellofemoral joint
 - Tibiofemoral joint

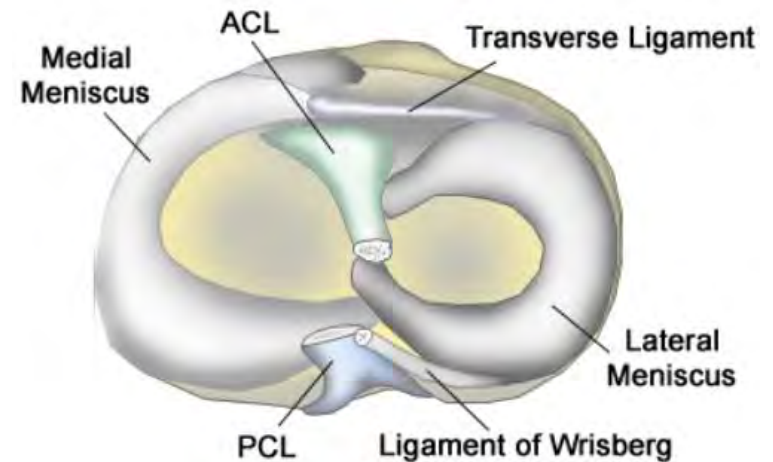


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<https://www.orthobullets.com/recon/9065/knee-biomechanics>

The Knee

- Complex joint!
- Meniscus – shock absorber
- Articular Cartilage – Smooth surface (less friction than ice on ice)
- BOTH mostly avascular meaning they DON'T HEAL if damaged



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<https://www.orthobullets.com/recon/9065/knee-biomechanics>

The Knee

- Working together, our knees can accomplish incredible things!

Activity	Force	% Body Weight	Pounds of Force
Walking	850 N	$\frac{1}{2} \times \text{BW}$	100lbs
Bike	850 N	$\frac{1}{2} \times \text{BW}$	100lbs
Stair Ascend	1500 N	$3.3 \times \text{BW}$	660lbs
Stair Descend	4000 N	$5 \times \text{BW}$	1000lbs
Jogging	5000 N	$7 \times \text{BW}$	1400lbs
Squatting	5000 N	$7 \times \text{BW}$	1400lbs
Deep Squatting	15,000 N	$20 \times \text{BW}$	4000lbs

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>>>



?

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<https://www.orthobullets.com/recon/9065/knee-biomechanics>

The Painful Knee

- NO WONDER KNEE INJURIES ARE SO COMMON!



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The Painful Knee

A LEADING CAUSE OF KNEE PAIN:

OSTEOARTHRITIS

A breakdown in the cartilage of joints.

When this cushioning cartilage wears out, bones begin to rub causing: pain, stiffness and damage.

HOW MANY PEOPLE SUFFER FROM OSTEOARTHRITIS OF THE KNEE?

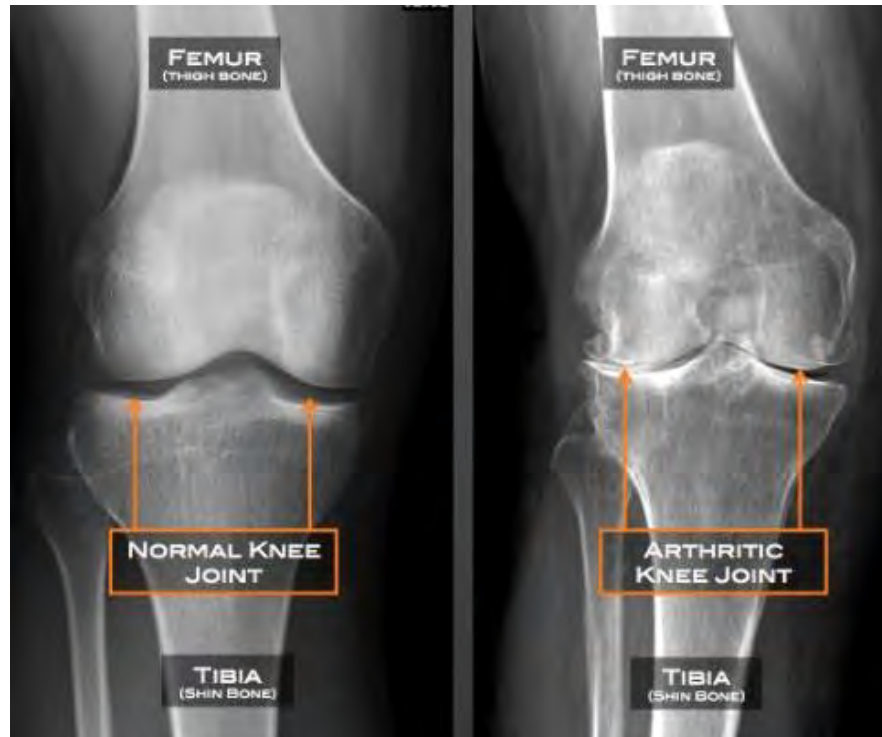
19 MILLION

That's 1 out of every 5 Americans over 40 years old.

OA is the most common form of arthritis and a leading cause of disability worldwide

The Painful Knee

- Determine the cause of pain
 - Examination, X-ray and diagnostic interventions
 - For sake of this talk....



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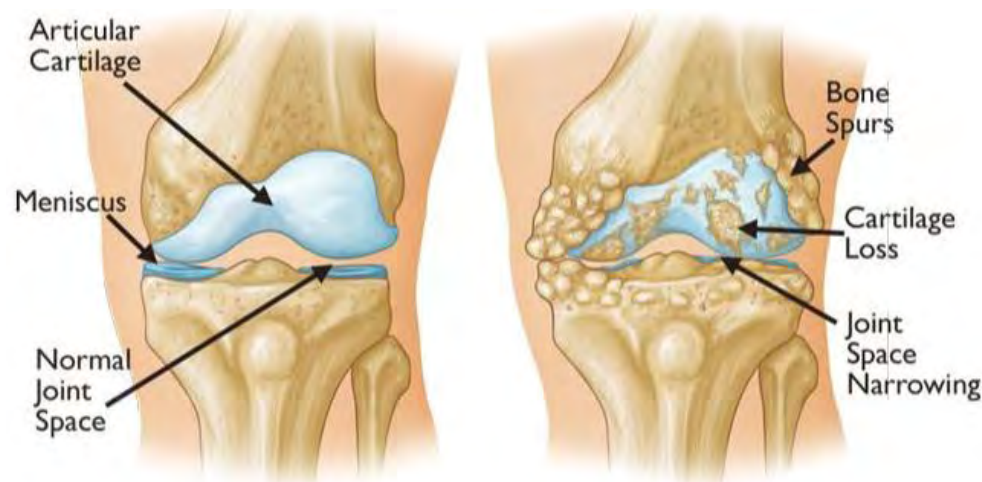
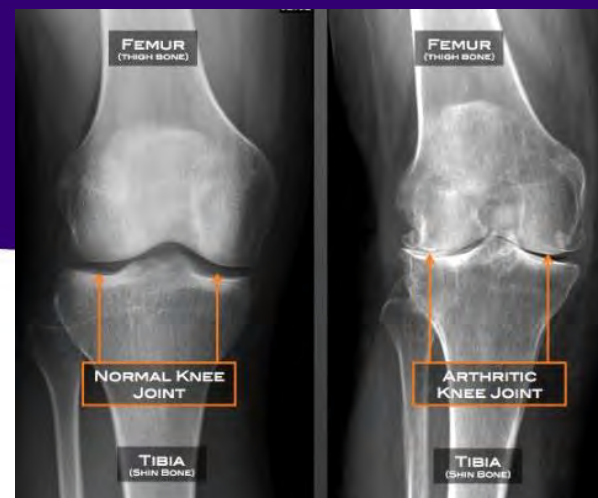
<https://www.orthobullets.com/recon/12287/knee-osteoarthritis>

The Painful Knee

- Degenerative Knee Disorders

- Knee Osteoarthritis
- Post-traumatic arthritis
- Infectious arthritis
- Congenital Abnormality
- Inflammatory arthritis
 - Rheumatoid Arthritis
 - Psoriatic Arthritis
 - Etc.

The list goes on.... lead to the SAME ENDPOINT

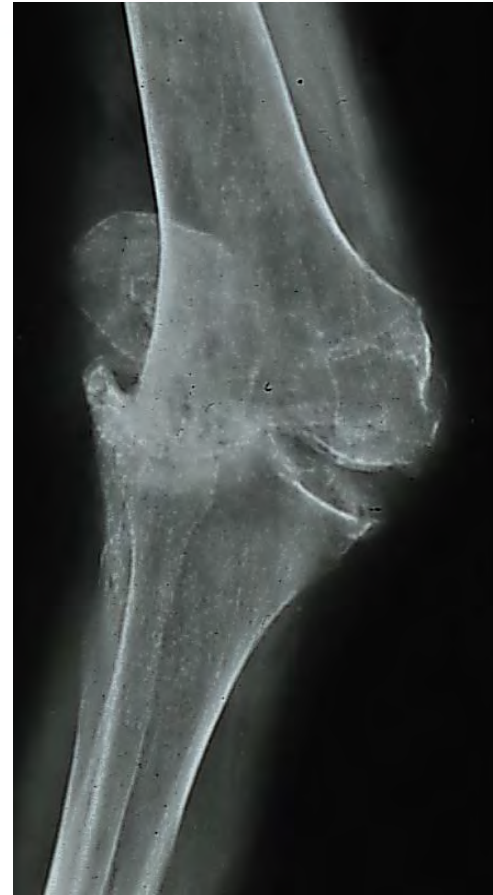


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<https://orthoinfo.aaos.org/en/diseases--conditions/arthritis-of-the-knee/>

The Painful Knee

- Presenting Symptoms
 - Pain with activity
 - Rough surface – inflammation of synovium
 - Bony bruising (edema)
 - Meniscus degenerative tearing
 - Pain develops at night or at rest
 - Activity induced swelling
 - Worsening stiffness
 - Mechanical symptoms
 - Instability - main ligaments loose/tight
 - Locking/Catching – debris in knee
 - Congenital Abnormality



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When to consider knee replacement?

- Non-operative options for degenerative joint disease of the knee



Management of Osteoarthritis of the Knee (Non-Arthroplasty)

Evidence-Based Clinical Practice Guideline

Adopted by:

The American Academy of Orthopaedic Surgeons Board of Directors
August 31, 2021

Endorsed by:

James B. Chen MD



<https://www.aaos.org/globalassets/quality-and-practice-resources/osteoarthritis-of-the-knee/oak3cpg.pdf>

When to consider knee replacement?

- The best options – 4 of 4 stars

Supervised Exercise

Supervised exercise, unsupervised exercise, and/or aquatic exercise are recommended over no exercise to improve pain and function for treatment of knee osteoarthritis.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★★ STRONG EVIDENCE

Patient Education

Patient education programs are recommended to improve pain in patients with knee osteoarthritis

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★★ STRONG EVIDENCE

Oral NSAIDs

Oral NSAIDs are recommended to improve pain and function in the treatment of knee osteoarthritis when not contraindicated.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★★ STRONG EVIDENCE

Oral Acetaminophen

Oral Acetaminophen is recommended to improve pain and function in the treatment of knee osteoarthritis when not contraindicated.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

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★★★★ STRONG EVIDENCE

Topical Treatments

Topical NSAIDs should be used to improve function and quality of life for treatment of osteoarthritis of the knee, when not contraindicated.

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★★★★ STRONG EVIDENCE

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<https://www.aaos.org/globalassets/quality-and-practice-resources/osteoarthritis-of-the-knee/oak3cpg.pdf>

When to consider knee replacement?

- Other good options – 3 of 4 stars

Intra-articular Corticosteroids

Intra-articular (IA) corticosteroids could provide short-term relief for patients with symptomatic osteoarthritis of the knee.

[Management of Osteoarthritis of the Knee \(Non-Arthroplasty\) \(3rd Edition\)](#)

Endorsed by: AAHKS [Cite this recommendation](#)

★★★ MODERATE EVIDENCE

Canes

Canes could be used to improve pain and function in patients with knee osteoarthritis.

[Management of Osteoarthritis of the Knee \(Non-Arthroplasty\) \(3rd Edition\)](#)

Endorsed by: AAHKS [Cite this recommendation](#)

★★★ MODERATE EVIDENCE

Braces

Brace treatment could be used to improve function, pain and quality of life in patients with knee osteoarthritis.

[Management of Osteoarthritis of the Knee \(Non-Arthroplasty\) \(3rd Edition\)](#)

Endorsed by: AAHKS [Cite this recommendation](#)

★★★ MODERATE EVIDENCE

Neuromuscular Training

Neuromuscular training (i.e. balance, agility, coordination) programs in combination with traditional exercise could be used to improve performance-based function and walking speed for treatment of knee osteoarthritis.

[Management of Osteoarthritis of the Knee \(Non-Arthroplasty\) \(3rd Edition\)](#)

Endorsed by: AAHKS [Cite this recommendation](#)

Partial Meniscectomy

Arthroscopic partial meniscectomy can be used for the treatment of meniscal tears in patients with concomitant mild to moderate OA who have failed physical therapy or other nonsurgical treatments.

[Management of Osteoarthritis of the Knee \(Non-Arthroplasty\) \(3rd Edition\)](#)

Endorsed by: AAHKS [Cite this recommendation](#)

★★★ MODERATE EVIDENCE

When to consider knee replacement?

- Limited evidence – Maybe?

Oral/Dietary Supplements

The following supplements may be helpful in reducing pain and improving function for patients with mild to moderate knee osteoarthritis; however, the evidence is inconsistent/limited and additional research clarifying the efficacy of each supplement is needed.

- a) Turmeric
- b) Ginger extract
- c) Glucosamine
- d) Chondroitin
- e) Vitamin D

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★★★ LIMITED EVIDENCE

Manual Therapy

Manual therapy in addition to an exercise program may be used to improve pain and function in patients with knee osteoarthritis.

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Endorsed by: AAHKS Cite this recommendation

★★★ LIMITED EVIDENCE

Laser Treatment

FDA-approved laser treatment may be used to improve pain and function in patients with knee osteoarthritis

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★★★ LIMITED EVIDENCE

Extracorporeal Shockwave Therapy

Extracorporeal shockwave therapy may be used to improve pain and function for treatment of osteoarthritis of the knee.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★ LIMITED EVIDENCE

When to consider knee replacement?

- Limited evidence – Maybe?

Acupuncture

Acupuncture may improve pain and function in patients with knee osteoarthritis.

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★★★ LIMITED EVIDENCE

Tibial Osteotomy

High tibial osteotomy may be considered to improve pain and function in properly indicated patients with unicompartmental knee osteoarthritis.

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Endorsed by: AAHKS Cite this recommendation

★★★ LIMITED EVIDENCE

Transcutaneous Electrical Nerve Stimulation

Modalities that may be used to improve pain and/or function in patients with knee osteoarthritis include:

a) Transcutaneous Electrical Nerve Stimulation (pain)

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★ LIMITED EVIDENCE

Platelet-rich Plasma

Platelet-rich plasma (PRP) may reduce pain and improve function in patients with symptomatic osteoarthritis of the knee.

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Endorsed by: AAHKS Cite this recommendation

★★★ LIMITED EVIDENCE

When to consider knee replacement?

- May not provide benefit for ROUTINE use – of course can discuss these options with your surgeon

Lateral Wedge Insoles

Lateral wedge insoles are not recommended for patients with knee osteoarthritis.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★★ STRONG EVIDENCE

Hyaluronic Acid

Hyaluronic acid intra-articular injection(s) is not recommended for routine use in the treatment of symptomatic osteoarthritis of the knee.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★ MODERATE EVIDENCE

Oral Narcotics

Oral narcotics, including tramadol, result in a significant increase of adverse events and are not effective at improving pain or function for treatment of osteoarthritis of the knee.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

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★★★★ STRONG EVIDENCE

Lavage/Debridement

Arthroscopy with lavage and/or debridement in patients with a primary diagnosis of knee osteoarthritis is not recommended.

Management of Osteoarthritis of the Knee (Non-Arthroplasty) (3rd Edition)

Endorsed by: AAHKS Cite this recommendation

★★★ MODERATE EVIDENCE

<https://www.aaos.org/globalassets/quality-and-practice-resources/osteoarthritis-of-the-knee/oak3cpg.pdf>

When to consider knee replacement?

- When those options fail...



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Knee Replacement

- Goal – to restore pain free function, stability balance, and motion
- Despite the name, actually thought of as a "soft-tissue balancing" procedure

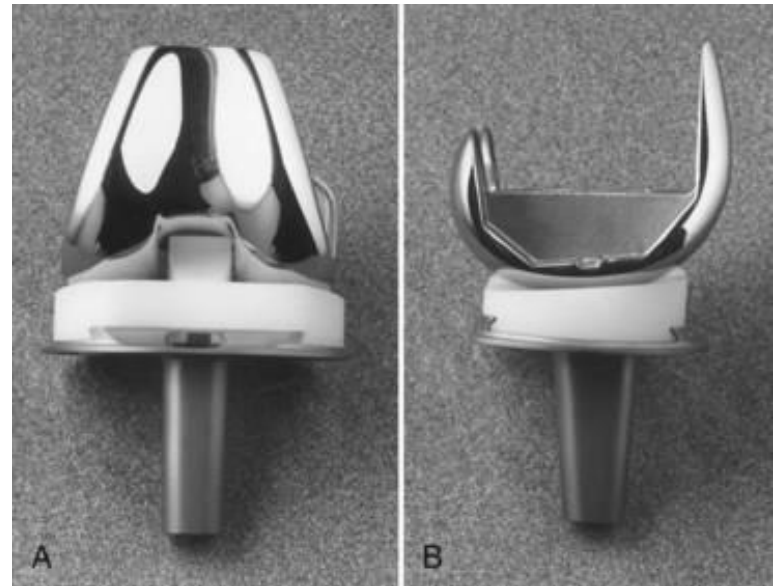
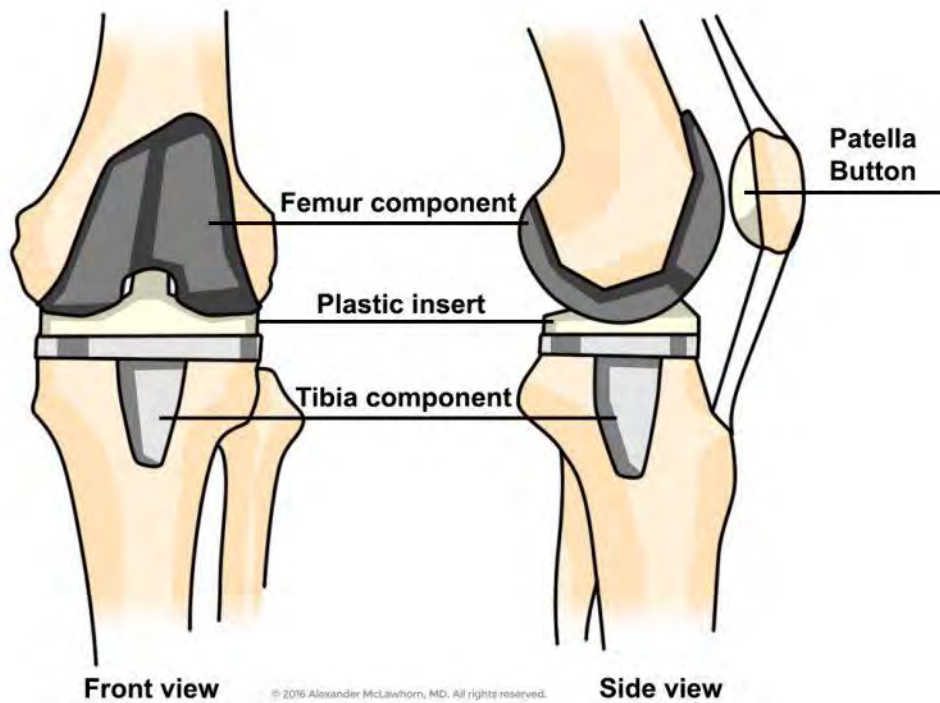
Knee Replacement



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Knee Replacement



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Modern “total condylar knee” -1974

Knee Replacement

- 1974 = Modern?

What advancements have been made?

Knee Replacement

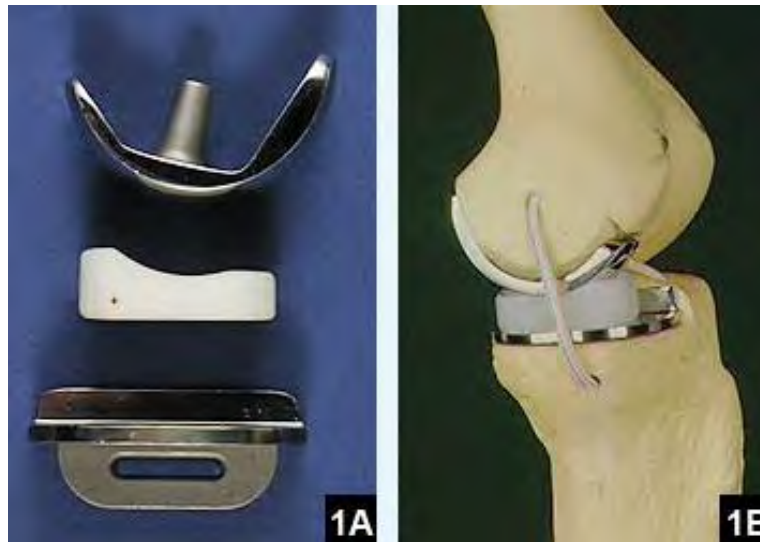
- Enhanced recovery protocols

- Hydrate
- Multimodal pain control
- Blocks
- Medication complication prevention
- Early mobilization
- Preoperative education



Knee Replacement

- Partial Knee replacement
 - 1982 – First Oxford partial knee replacement performed.



- Spherical on flat design
- Remains one of the most popular designs

Knee Replacement

- Partial vs Total – What is the difference?

Partial Knee Replacement

- Pros
 - Faster recovery
 - Less invasive
 - Easier revision
 - High function
- Cons
 - Progressive arthritis
 - Almost lasts as long
 - Stress fracture
 - Unable to correct deformity

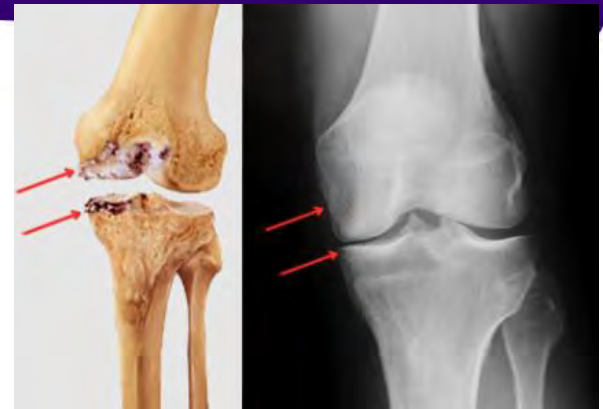
Total Knee Replacement

- Pros
 - Replaces entire joint surface
 - Can correct deformity
 - Longevity?
- Cons
 - Longer recovery
 - More difficult revision

*****MUST be appropriate candidate!**

Knee Replacement

- Indications for partial knee replacement:



Initial Kozinn & Scott Criteria	Current Opinion (agree/disagree)
isolated medial compartmental disease	patellofemoral arthropathy is not absolute contraindication
no lateral joint line tenderness	
intact ACL	ACL deficient knee is not absolute
noninflammatory arthropathy	
weight under 82 kg	BMI is poorly correlated in recent studies
correctable varus deformity < 5°	< 10° varus, < 5° valgus
over 60 years old	UKA is successful in < 60 years old patients
-flex contracture < 5°	< 15°
-Range of motion > 90°	

Outcome of Unicondylar Knee Arthroplasty vs Total Knee Arthroplasty for Early Medial Compartment Arthritis: A Randomized Study

Vikas Kulshrestha¹, Barun Datta¹, Santhosh Kumar², Gaurav Mittal¹

Affiliations + expand

PMID: 28065624 DOI: 10.1016/j.arth.2016.12.014

V. Kulshrestha et al. / The Journal of Arthroplasty 32 (2017) 1460–1469

1467

Table 3
Patient-Reported Activity, Function, and Performance in Bilateral TKA and UKA Groups at 2-y of Follow-Up.

Parameter	UKA			TKA			P Value	Effect Size	Test
	N	Mean	SD	N	Mean	SD			
Knee flexion	36	4.9	9.1	36	5.8	13.5			
KOS-ADLS (max 100) ^a	36	50.0	9.8	36	47.0	13.0	.2143	0.27	t-Test
HAAS ^a	36	3.1	1.6	36	2.8	1.7	.2010	0.18	t-Test
Oxford score ^a	36	17.1	4.1	36	16.8	5.5			
Delaware index ^a									
Timed Up and Go (s)	36	7.7	2.7	36	6.9	2.7			
Stair climb test (s)	36	8.8	3.5	36	7.2	2.9			
Self-paced walk test (s)	36	6.2	3.4	36	4.9	1.7			
Chair to stand test (s)	36	3.0	0.8	36	2.9	0.7			
Satisfaction (%) ^a	36	59.0	8.3	36	55.7	9.9	.7699	0.36	t-test
EQ-5D (VAS) ^a	36	43.3	13.9	36	39.4	11.8			

Values in bold are the Cohen's d (effect size) which shows the magnitude of the difference (d = 0.20 is small, d = 0.5 is medium and d = 0.8 is large).

UKA, unicondylar knee arthroplasty; TKA, total knee arthroplasty; SD, standard deviation; KOS-ADLS, Knee Outcome Scale-Activities of Daily Living Scale; HAAS, High Activity Arthroplasty Score; EQ-5D (VAS), European Quality of Life index (visual analog scale).

^a Gain at 2-y of follow-up.

Randomized Controlled Trial > [J Arthroplasty](#). 2017 May;32(5):1460-1469.
doi: 10.1016/j.arth.2016.12.014. Epub 2016 Dec 23.

Outcome of Unicondylar Knee Arthroplasty vs Total Knee Arthroplasty for Early Medial Compartment Arthritis: A Randomized Study

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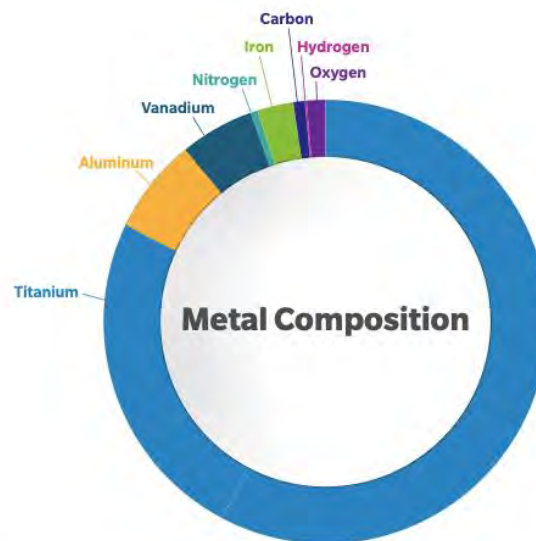
Affiliations + expand

PMID: 28065624 DOI: [10.1016/j.arth.2016.12.014](#)

- UKA recover faster and may have better function
- Earlier revisions however revision surgery is easier and can typically get primary total knee implants

Knee Replacement

- Material used
 - Metal varies – typically Cobalt Chromium alloy vs Titanium alloy
 - **Nickle free options – Oxinium (ceramic zirconium) , Tivanium (nitriding process), Gold, others?**

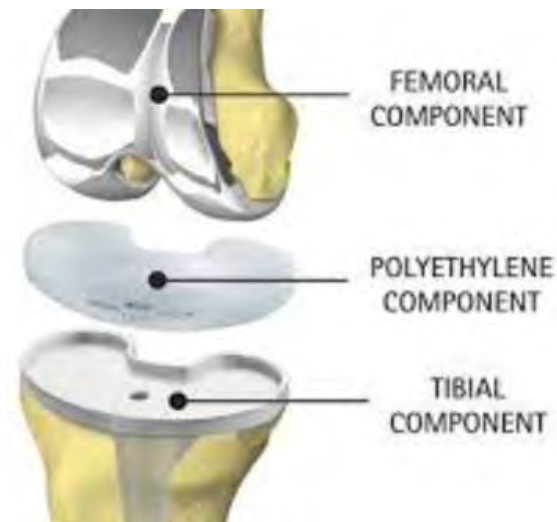
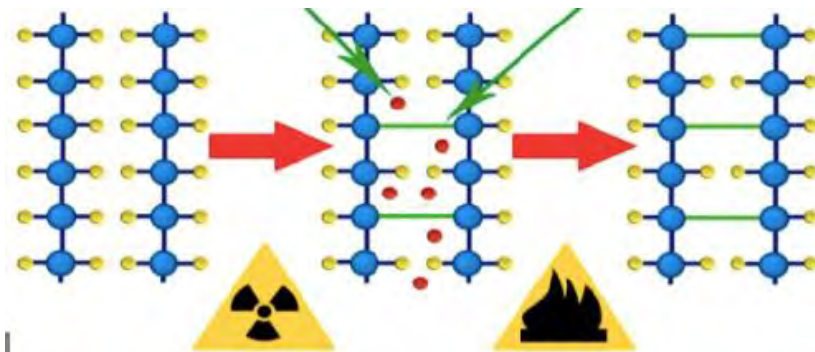


The titanium alloy used with the Persona Ti-Nidium Knee has no deliberate addition of common metal sensitizers

Figure 1
Persona Ti-Nidium Knee
Metal Composition

Knee Replacement

- Material used
 - Bearing surface – **highly cross-linked polyethylene** significantly improved wear properties in the late 90s



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Knee Replacement

- Fixation method

- Cement fixation



- Press-fit/Uncemented

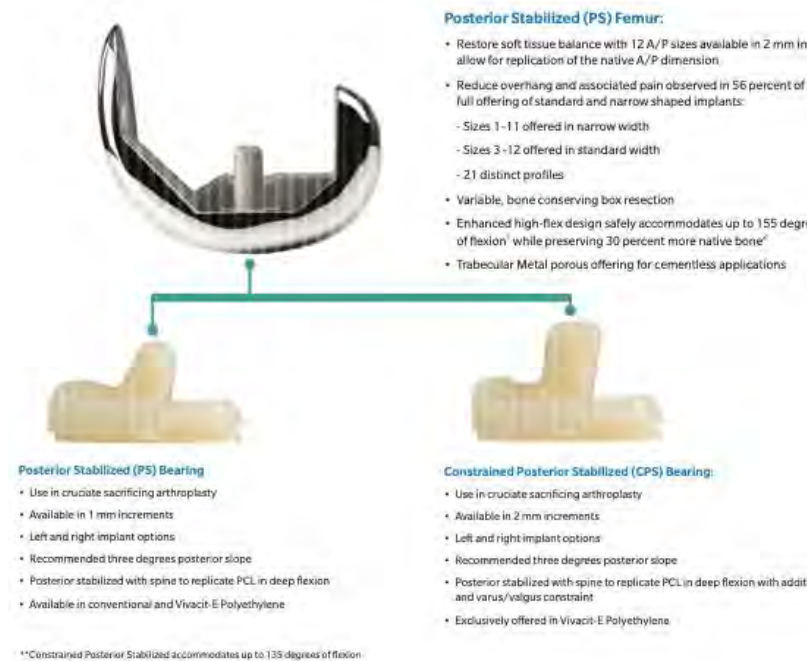
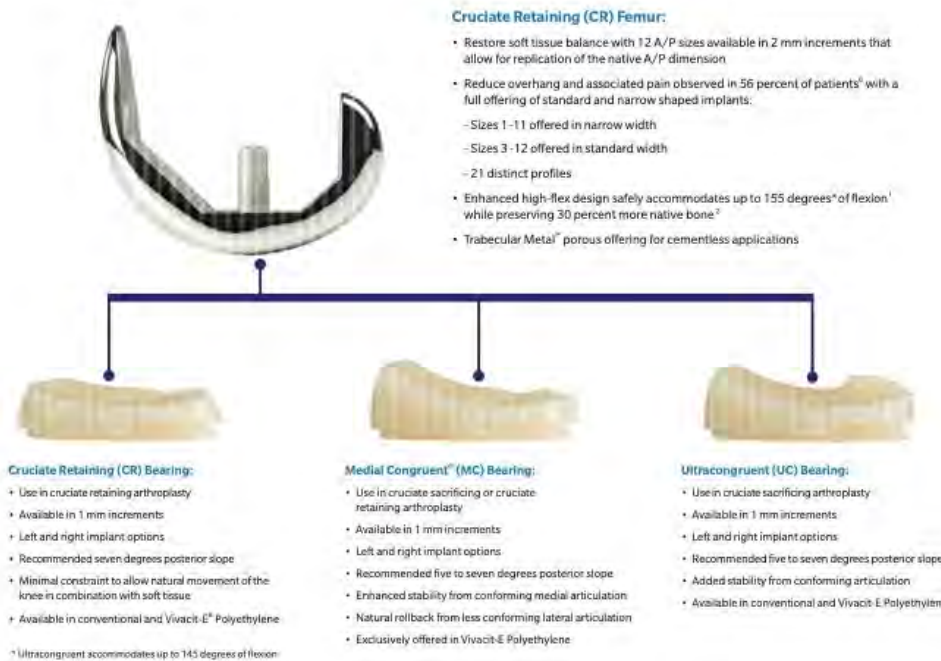
- Need good bone quality
 - Longevity for younger patients?



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Knee Replacement

Bearing surface design



Knee Replacement

- Remember – how does the normal knee function
- Pivot shift
- Lateral mobility
- Rollback
- High flex and posterior dwell points



Knee Replacement

- Those are the implant → how are they placed?
 - Mechanical vs Kinematic vs in between
 - Measured resection vs Gap balancing



Knee Replacement

- All techniques can achieve the goal of soft tissue balance, but the way we get there is changing

Knee Replacement

- Robotic and navigation assisted total knee replacement
- Once you have a specific target
 - Improves accuracy
 - Customized implant positioning
 - Gap/soft tissue balance objective measurements
 - Possibly more predictable release – less invasive



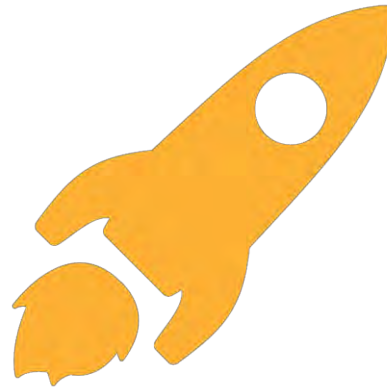
KneeAlign[®] surgery for Total & Partial Knee Replacement



KneeAlign® is GPS-guided knee surgery

Technology that put a man on the moon... is now guiding your knee.

KneeAlign provides me real-time feedback on where I'm putting your knee implant, and ensures an accurate and precise result.



KneeAlign® is GPS-guided knee surgery

Today, we rely on the phone in our pocket to get us where we're going.

I use KneeAlign the same way. It provides me real-time feedback on where I'm putting the knee implant, and ensures an accurate and precise result.



KneeAlign® Knee Surgery

- + **KneeAlign guides the implant into alignment with the mechanics of your tibia**
 - Virtually reconstructs your specific tibial anatomy
 - Provides me data in real-time to guide me to my goal
- + **The result:**
Precisely aligned Tibial Implant

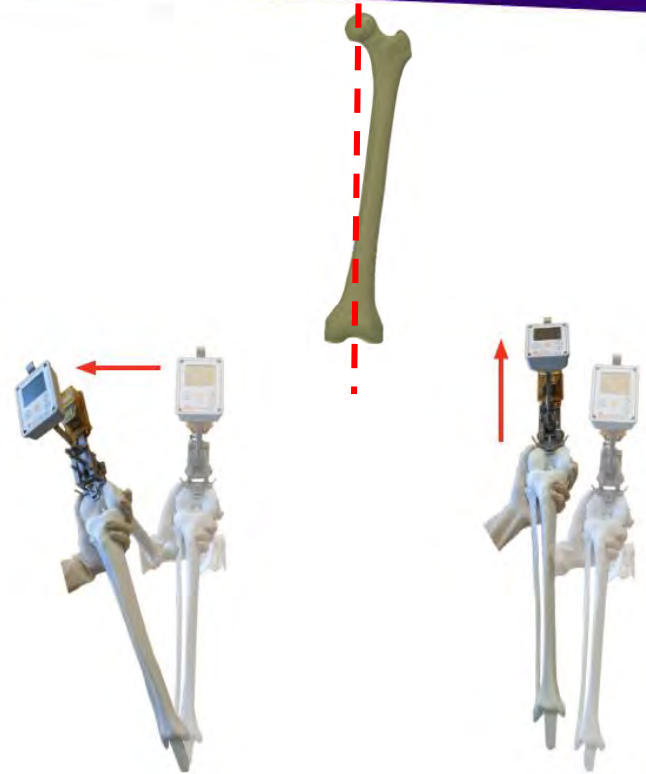


KneeAlign® Knee Surgery

+ KneeAlign guides the implant into alignment with the mechanics of your femur

- Virtually reconstructs the mechanics of your femur
- Provides me data in real-time to guide the implant location
- Allows me to preserve bone

+ The result: Precisely aligned Femoral Implant



Knee Replacement

- Case Example



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Knee Replacement

- Future? – smart implants, AR/VR, virtual perioperative care, smart OR, AI monitoring programs

Knee Replacement

Questions?