

Triathlon[®]

knee replacement



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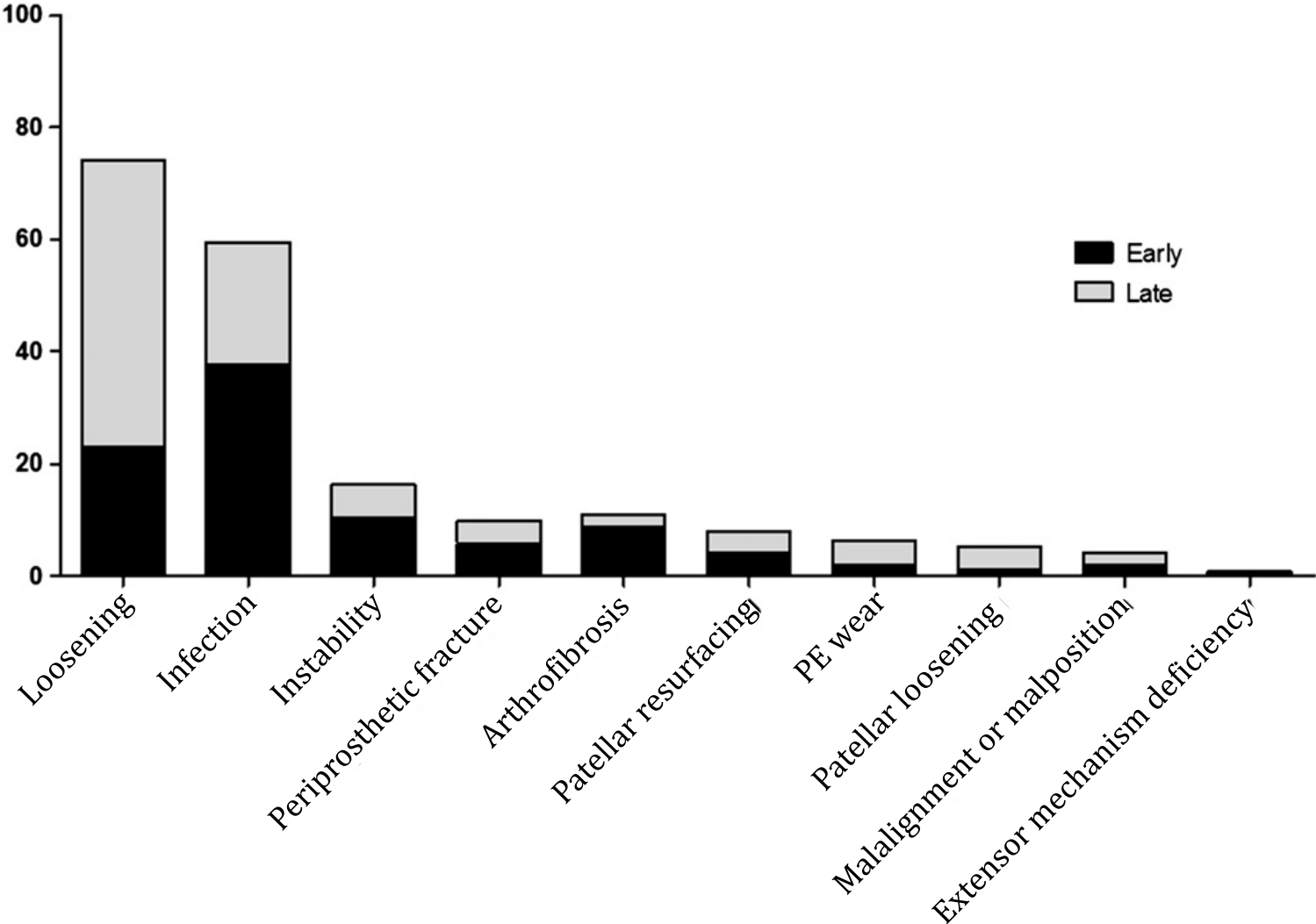
Topics

- Why single radius?
- Designed to work with the body
- Clinical data
- Orientation and fit
- System options
- My experience with Triathlon TKA

Why single radius?

Mid-flexion stability¹⁻⁵
Quadriceps efficiency⁶

Why do TKAs fail?⁷



What is mid-flexion instability?

The knee is stable in extension and 90° of flexion but symmetrically unstable during varus-valgus testing at 30° to 45° of flexion⁸

Some common symptoms of instability

Common expressions used by patients:

- “Giving way” or “Just will not hold them up”⁹
- “Get their knee in gear” before starting to walk⁹
- Potential difficulty with ascending / descending stairs (attributed to instability, not to pain)¹⁰

Physical exam

Anterior or posterior drawer test¹¹



Potential factors contributing to mid-flexion instability following TKA

Technical error¹⁰

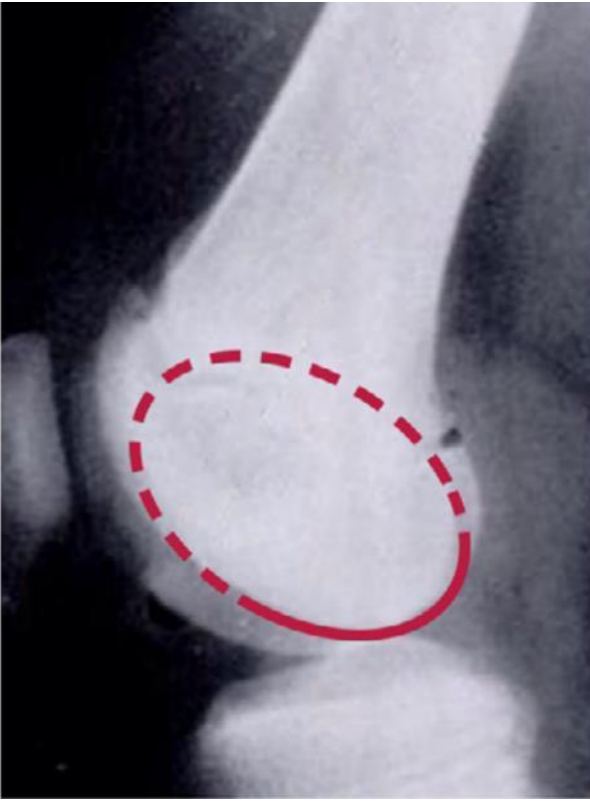
- Gap imbalance
- Joint-line malposition

Implant design^{1,3,5}

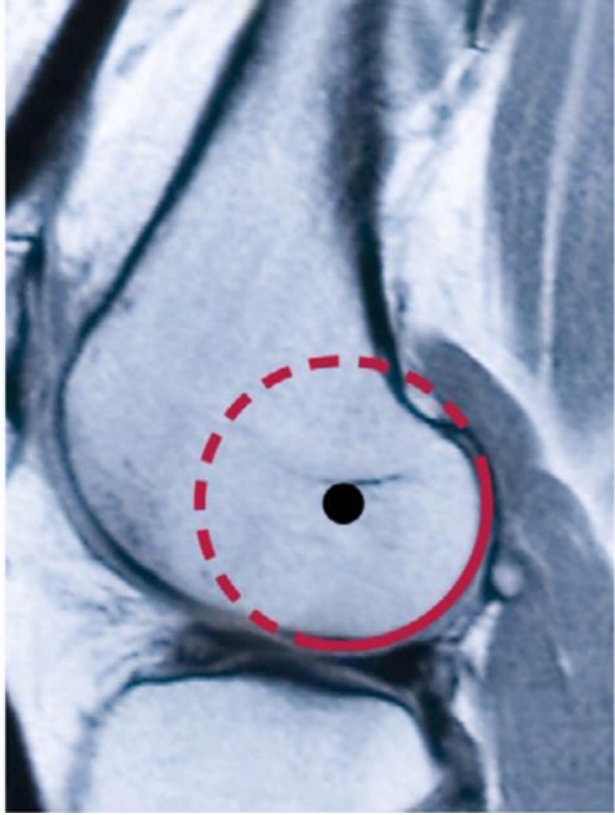
- Single vs. multi-radius

Single vs. multi-radius

Traditional ML perspective¹²



Modern TEA perspective¹³



Sagittal geometry

The posterior condyles are circular

Hollister et al.¹⁴

- Magnetic resonance (MR) images in planes perpendicular to the FE axis show a **circular** profile for the femoral condyles

Iwaki, Freeman et al.¹³

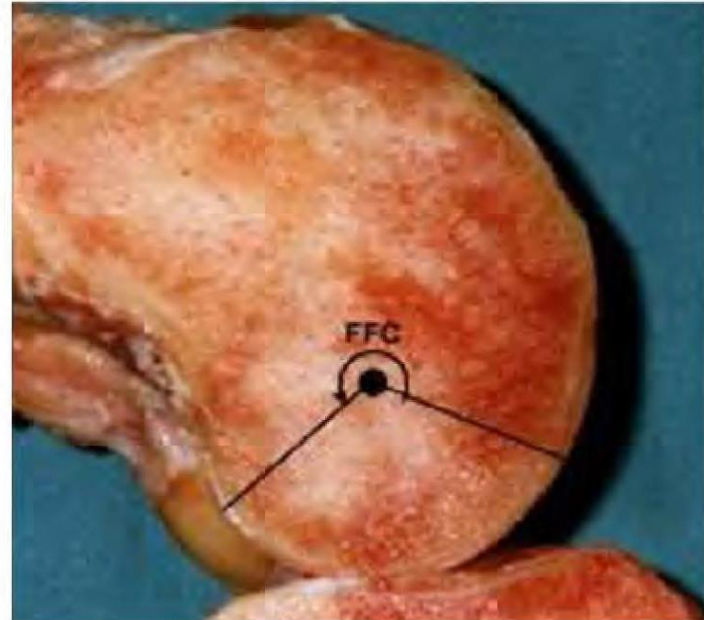
- The lateral condyle, like the medial condyle, is **circular** posteriorly



Motion in the normal knee

Stability¹²

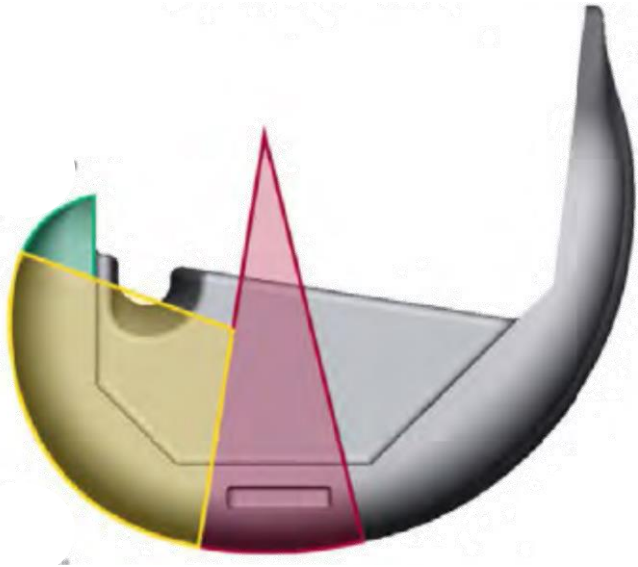
- Functional flexion arc from 10° to 110°
 - Consistent sagittal geometry
 - Single flexion / extension axis



Single vs. multi-radius

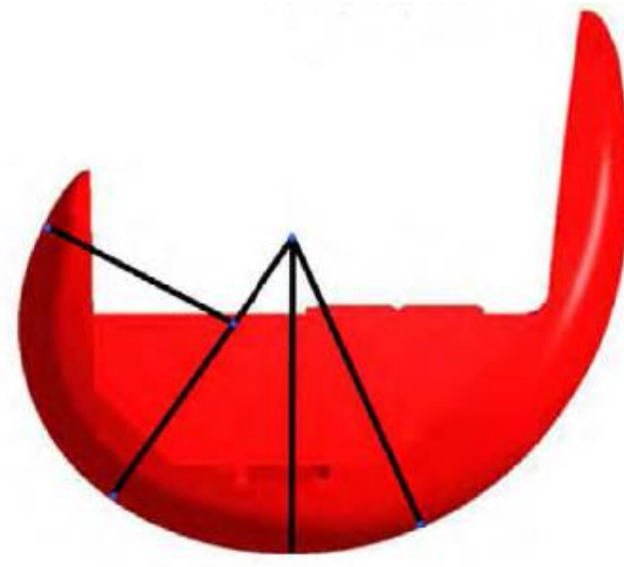
Single radius

- Circular sagittal geometry
- Single axis of rotation



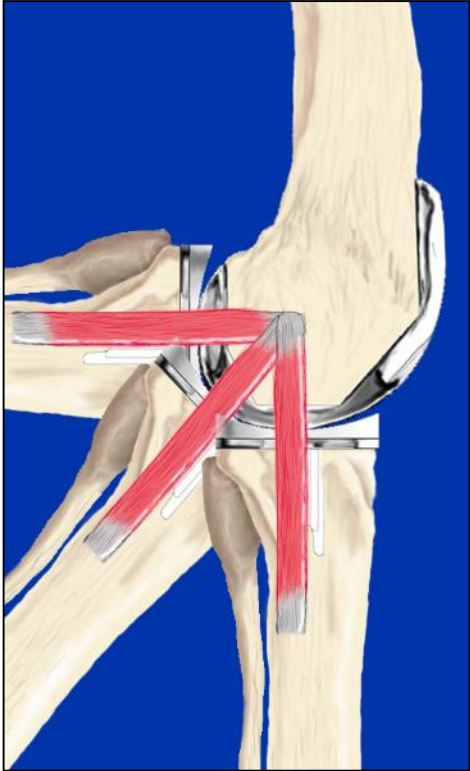
Multi-radius

- Variable sagittal geometry
- Multiple axes of rotation

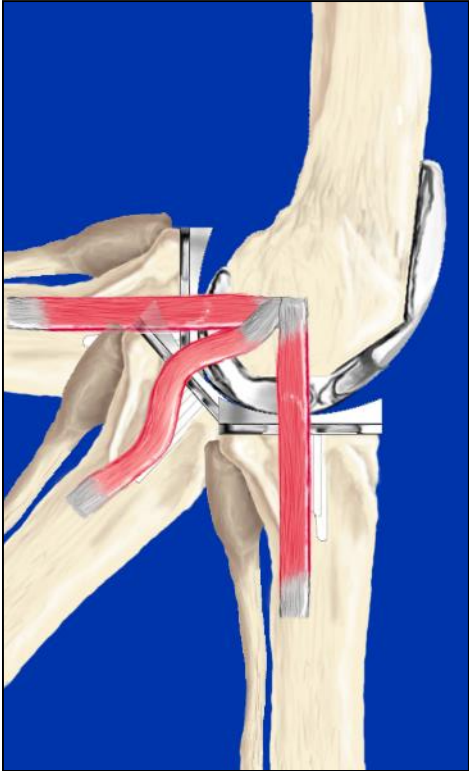


Single vs. multi-radius

Single radius

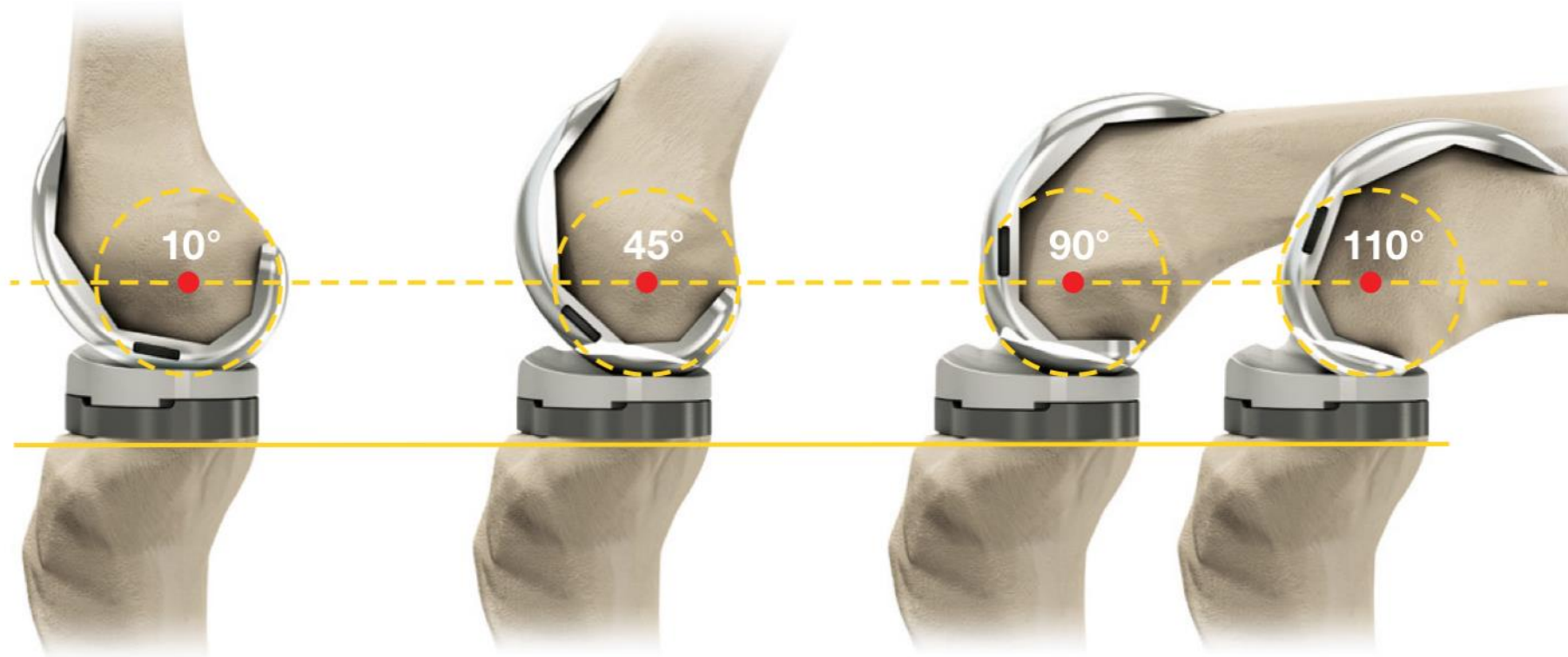


Multi-radius



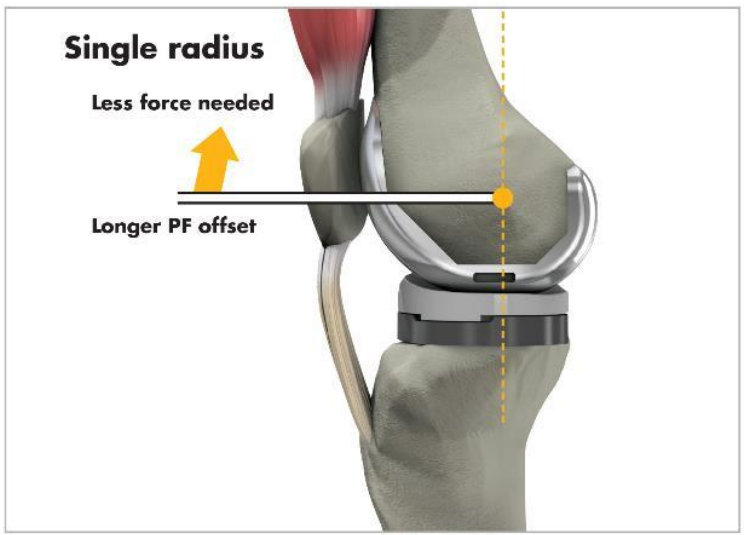
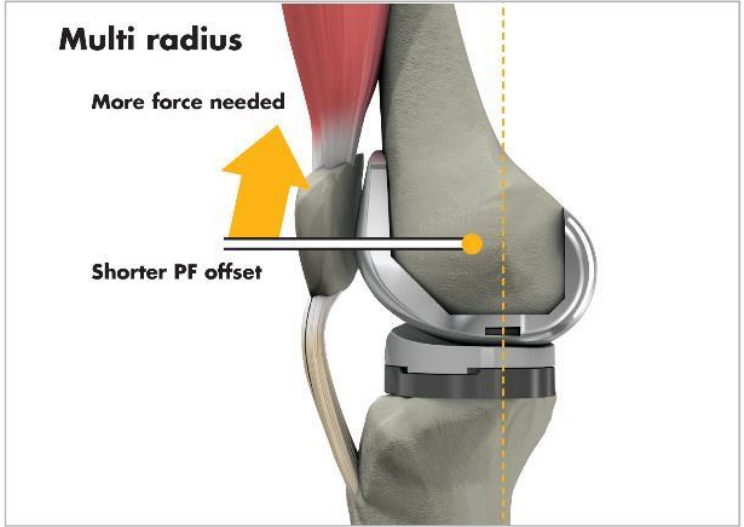
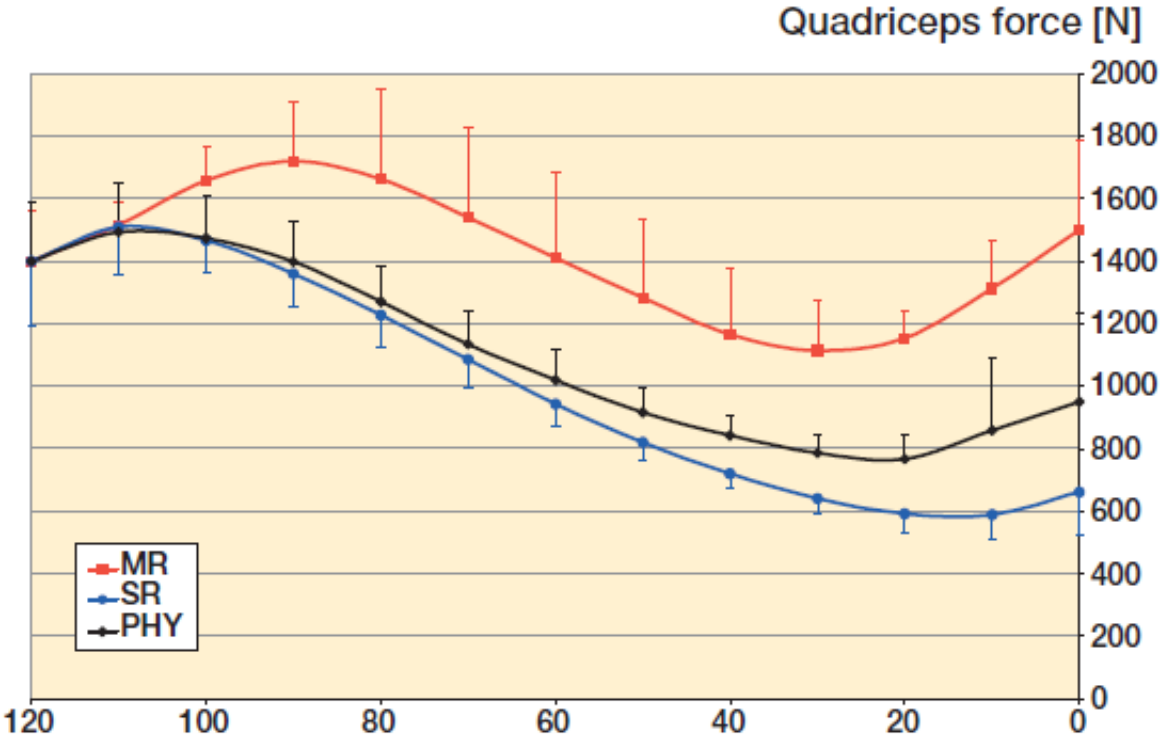
Single radius mid-flexion stability

The single radius knee replacement is designed to maintain ligament balance through the active range of motion, including mid-flexion.^{2,5,14} A study of patients who underwent a Mako SmartRobotics™ knee replacement showed that patients with Triathlon implants achieved mid-flexion stability when the knee was balanced in extension and flexion.⁴



Single radius quadriceps efficiency⁶

57% less force required for Triathlon single radius design to achieve extension compared to multi-radius design⁶

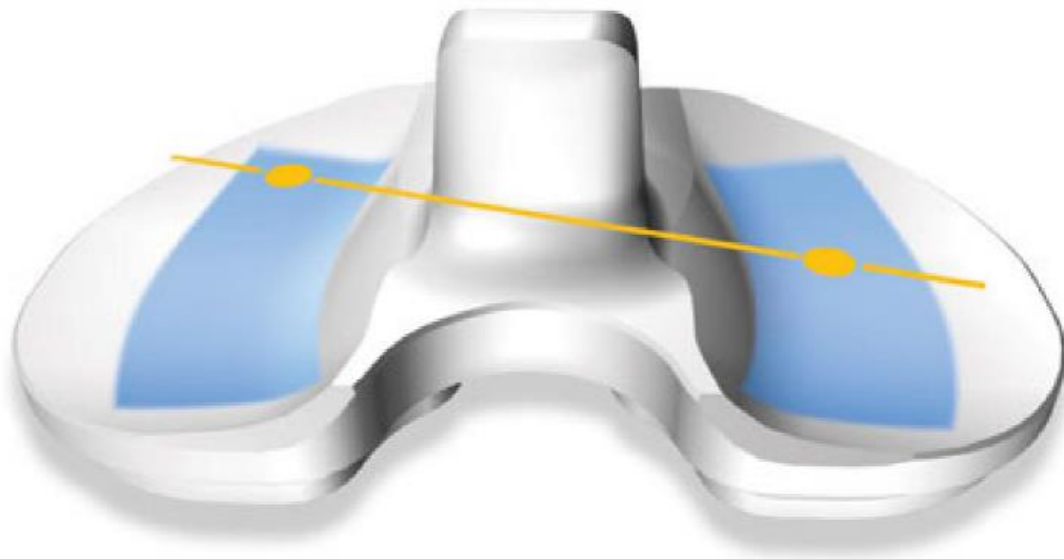


Designed to
work with the
body

Rotary arc
Flared, shorter posterior condyles
Post/cam engagement (PS)
Anatomic patellofemoral track

Rotary arc¹⁵

The Triathlon rotary arc design allows for +/- 20° of internal/external rotation and reduces contact stresses.¹⁵



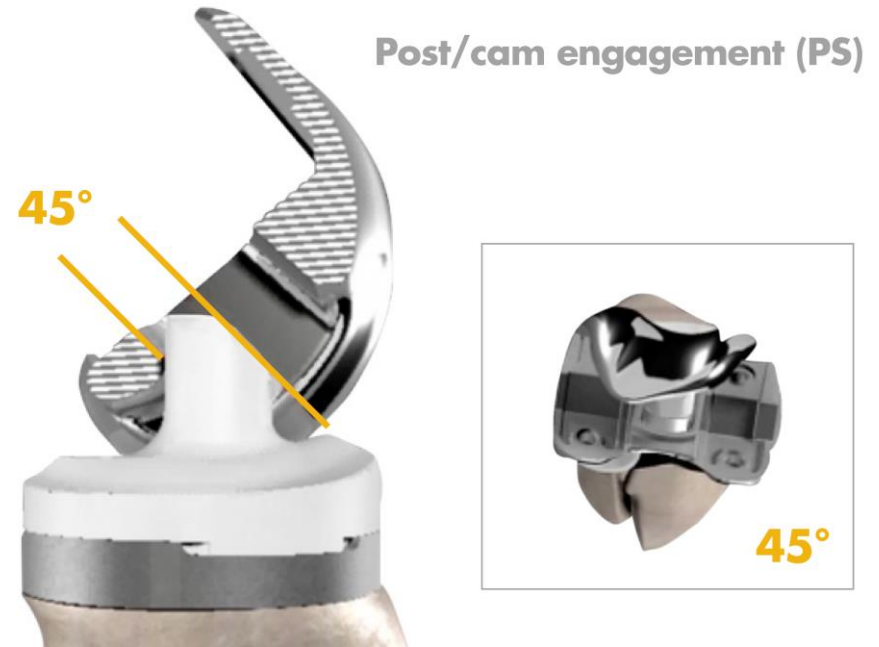
Flared, shorter posterior condyles¹⁵

Triathlon's shortened, flared posterior condyles are designed to facilitate the relaxation of the soft tissues to enable deep flexion without excessive slope.¹⁵



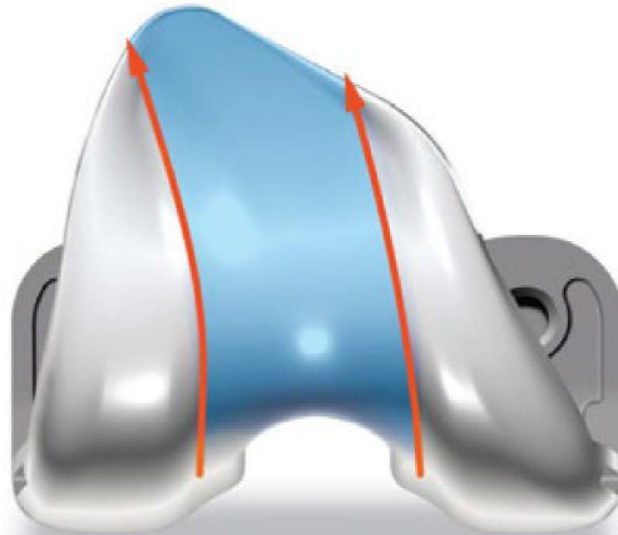
Post/cam engagement (PS)¹⁶

The Triathlon PS femur is designed to engage the post of the tibial insert at approximately 45°, where natural PCL loading occurs.¹⁶



Anatomic patellofemoral track¹⁷

Triathlon's deepened trochlear groove is designed to help relax the extensor mechanism, enable deeper flexion and reduce contact stresses exerted across the patella.¹⁷ Triathlon incorporates the same patellofemoral design as Duracon, which demonstrated <1% patellofemoral complication rates in multiple studies.^{18, 19}

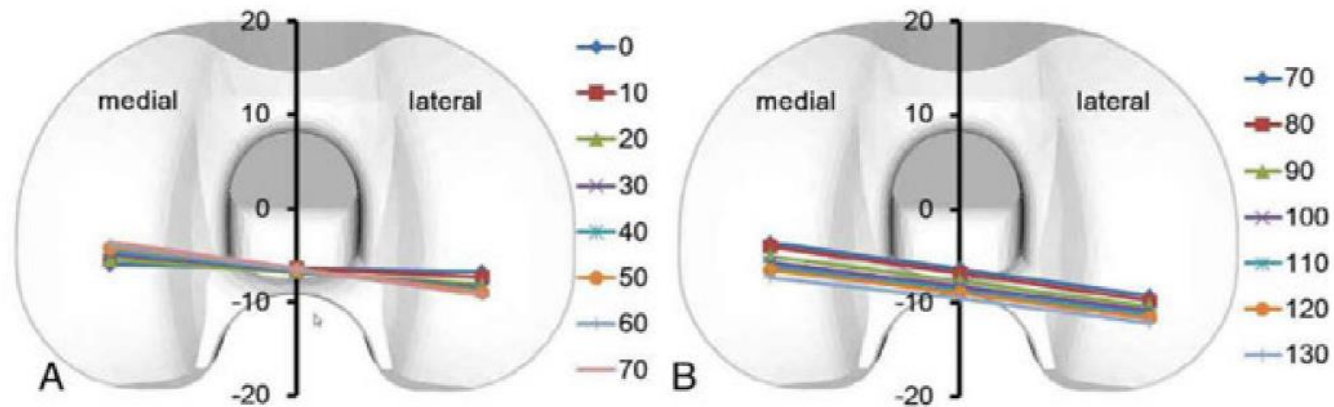


Clinical data

Single radius clinical outcomes

Stability

A fluoroscopic study on 20 Triathlon TKAs showed the femoral component was kinematically stabilized in mid-flexion ranges, and posterior femoral rollback occurred in deeper knee flexion with this knee design.³

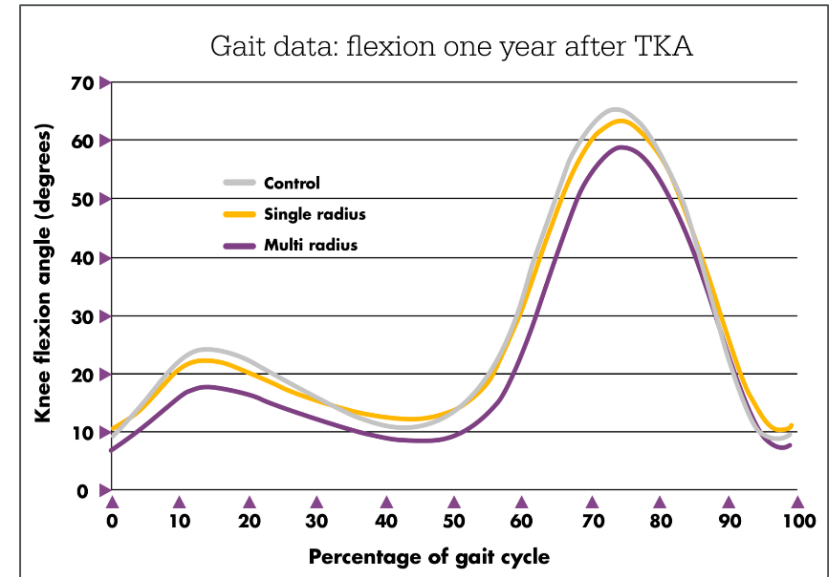


Single radius clinical outcomes

Stability

Gait study²⁰

- In a study that compared three cohorts of 16 patients who received single radius TKAs or multi-radius TKAs to healthy control knees, patients who received single radius TKA exhibited gait that more closely mimicked that of a healthy control knee.



Functional outcomes study¹

- In a study of 559 TKAs, KSS knee and function subscores for the single radius design showed an advantage over the multi-radius design as measured by pain, stability, flexion, ability to completely straighten the knee, stair climbing, walking and the amount of support needed from an assistive device.

Triathlon clinical outcomes

Patient-reported outcomes measurement (PROM)

Triathlon patient satisfaction reported in literature

- Hamilton et al. reported 90.5% at eight-year follow-up²¹
- Scott et al. reported 88% at 10-year follow-up²²
- Hamilton et al. reported 99% at three-year follow-up²³

Patients with Triathlon TKA continue to show favorable results with high implant survivorship and consistently maintained Oxford Knee Score (OKS) in a 10-year follow-up study²²

Time point	Preoperative	0.5 year	1 year	5 years	10 years
Mean OKS	18.8	34.3	36.3	37.3	34.7

Triathlon survivorship

Source	Triathlon all-cause survivorship at 10 years
Mistry et al. 2016 ²⁴	99.0%
Scott et al. 2019 ²²	97.9%
2019 National Joint Registry (UK/Wales) ²⁵	96.4%
2019 Australian Orthopaedic Association National Joint Replacement Registry ²⁶	96.2%/94.6% (CR/PS)
Orthopaedic Data Evaluation Panel (ODEP) ²⁷	10A*

The Orthopaedic Data Evaluation Panel (ODEP) is an independent organization in the U.K. that provides ratings for arthroplasty implants based on implant performance in National Joint Registries and peer-reviewed publications. The numbers, 3, 5, 7, 10, and 13, represent length of follow-up in years. The letters, A, A and B represent the quality of data. A represents strong evidence, B, represents acceptable evidence, and A* represents very strong evidence above A and B. ODEP rating accessed April 2019. Latest ODEP ratings can be found at www.odep.org.uk.

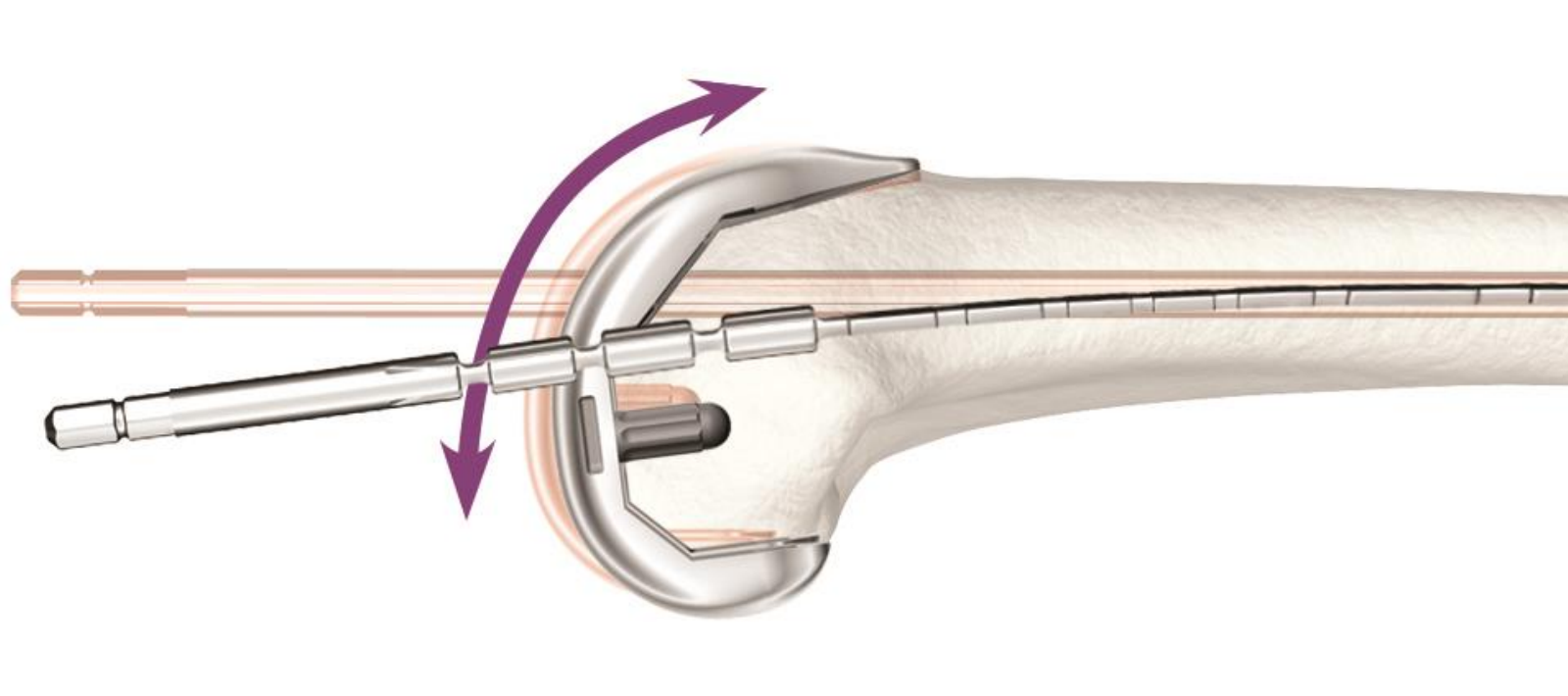
Orientation and fit

FlexRod

FlexRod

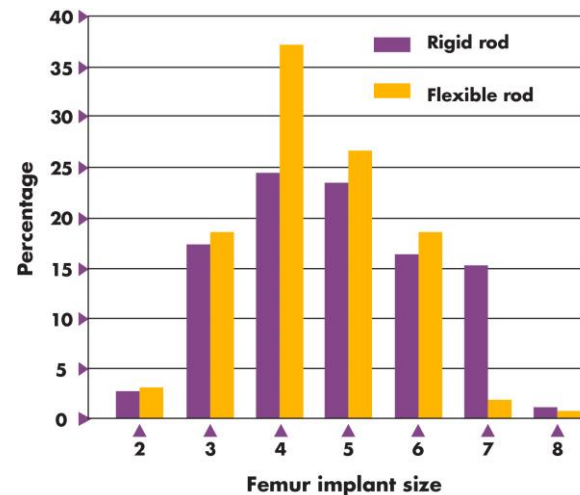
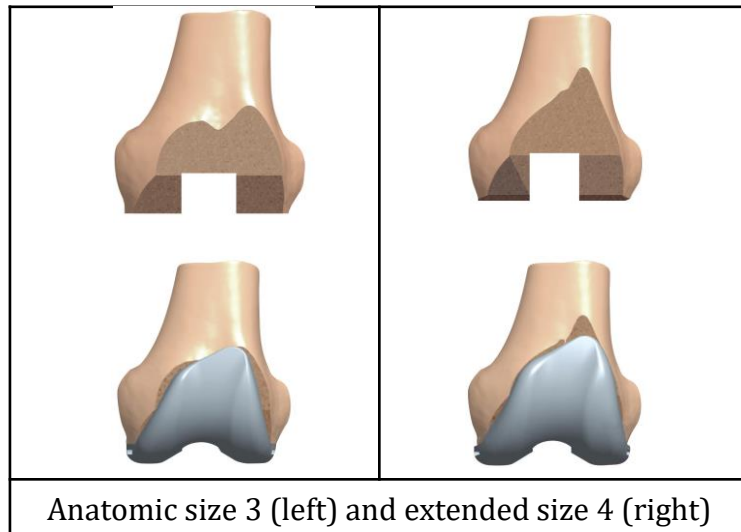
Potential for better fit

FlexRod is designed to aid component placement matched to individual patient anatomy in the sagittal plane.

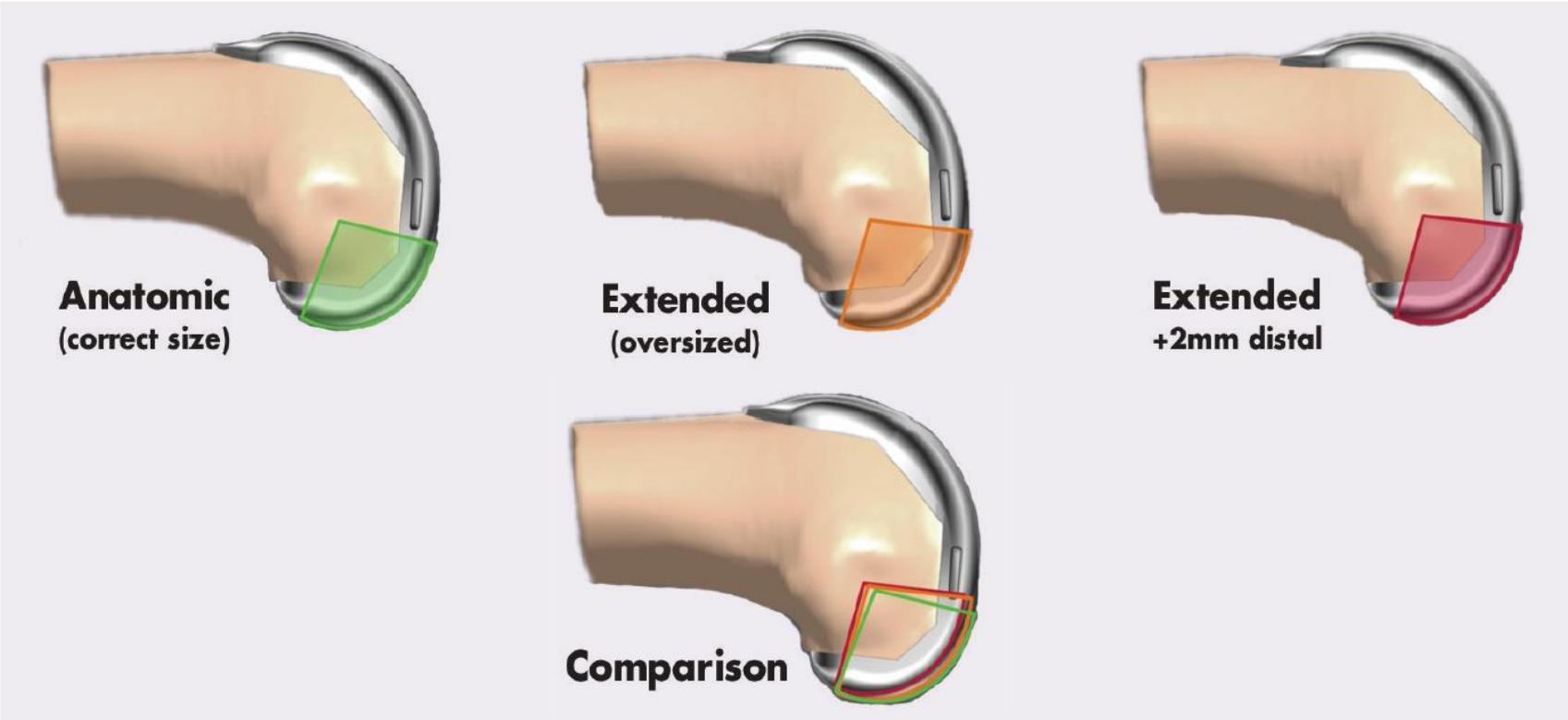


Sizing and fit with FlexRod

- Oversizing of the femoral component may lead to ML overhang. ≥ 3 mm ML overhang of the femoral components has been shown to be associated with increased knee pain.²⁸
- A CT scan–based study showed that the use of the FlexRod allowed Triathlon to fit 99.4% of patients.²⁹
- A retrospective clinical study that analyzed the femoral implant sizes of 277 patients using the rigid IM rod and 364 patients using the FlexRod rod showed that FlexRod reduced the risk of oversizing the femoral component.³⁰



Component positioning with FlexRod



Functional outcomes with FlexRod

- Prospective study of 100 TKA recipients
- The FlexRod cohort demonstrated improved KSS compared to the rigid rod cohort at two-year follow-up³⁰

ROM and KSS/Pain motion





ROM ³⁰						
	pre-op	6 weeks	3 months	1 year	2 years	% change at 2 years
Rigid	101.1	103.1	113.6	119.0	123.6	22.2%
Flexible	99.7	107.0	118.2	124.3	127.9	28.3%
% diff	-1.5%	3.8%	4.1%	4.4%	3.4%	6.1%

KSS Pain/Motion ³⁰						
	pre-op	6 weeks	3 months	1 year	2 years	% change at 2 years
Rigid	37.25	73.9	80.31	88.52	90.5	143.0%
Flexible	35.74	76.9	82.75	90.1	92.73	159.5%
% diff	-4.1%	4.1%	3.0%	1.8%	2.5%	16.5%

System options

Tibial constraint options

From CR, CS, PS to TS

Insert type		Varus/valgus constraint	Internal/external rotation	Maximum flexion
Cruciate Retaining (CR)		None	+/- 20°	150°
Condylar Stabilized (CS)		None	+/- 20°	150°
Posterior Stabilized (PS)		None	+/- 20°	150°
Total Stabilized* (TS)		+/- 2°	+/- 7°	135°



The Triathlon Condylar Stabilized (CS) Tibial Insert

CS Tibial Insert

- 2 mm more anterior height compared to CR insert to provide anterior stability
- Alternative for patients with an incompetent or sacrificed PCL



CS outcomes

- An in vivo investigation compared the intraoperative kinematics of CR, CS, and PS Triathlon inserts. For patients without intact PCLs, the Triathlon CS Inserts had a stable kinematic pattern that was similar to the Triathlon PS Insert.³¹
- In a study with five-year follow-up of patients with a sacrificed PCL, patients who received a Triathlon CS Tibial Insert demonstrated excellent clinical outcomes that were comparable to the results obtained with the Triathlon PS Tibial Insert.³²
- In a short-term follow-up study of patients with intact PCL, patients who received Triathlon CR and CS Tibial Inserts showed no differences in clinical survivorship and functional outcomes.³³

Triathlon Universal Baseplate

Universal Baseplate is compatible with the CR, CS, PS and TS insert

- TS Tibial Insert provides +/- 2° valgus-varus constraint but permits +/- 7° rotational freedom.
- In a study of 172 difficult primary TKAs with two-year follow-up and 41 difficult primary TKAs with five-year follow-up, all patients had good to excellent Knee Society Scores with good ROM and pain relief. No aseptic loosening or post failure was reported throughout the period of follow-up.³⁴

Universal Baseplate can be used with a stem extension

- A finite element analysis of the Universal Baseplate with a stem extension demonstrated a reduction of cement-implant interface compressive and shear stress when compared to a baseplate without a stem.³⁵



Triathlon Tritanium cementless TKA has demonstrated excellent clinical outcomes in multiple studies with five-year follow-up³⁶⁻³⁸



Triathlon Tritanium TKA survivorship with five-year follow-up	Source
99.5% implant survivorship in 228 Triathlon Tritanium Baseplates at five-year follow-up ³⁶	Journal of Knee Surgery
100% aseptic survivorship in 28 Triathlon Tritanium Baseplates with CR PA beaded femur at mean five-year follow-up ³⁷	Orthopaedic Research Society
98% all-cause survivorship in 261 Triathlon Tritanium Metal-Backed Patellae at mean 4.5-year follow-up ³⁸	Journal of Knee Surgery

Triathlon PA Beaded Femur survivorship with long-term follow-up	Source
96.8% all-cause survivorship for CR and 95.3% all-cause survivorship for PS at 10-year follow-up ²⁶	Australian Joint Registry
98% all-cause survivorship at mean eight-year follow-up for the Triathlon PS PA Beaded Femur ³⁹	Journal of Arthroplasty

X3 polyethylene

X3's patented⁴⁰ sequential irradiation and heat process allows for:

- **Mechanical strength:** Triathlon PS with X3 showed no mechanical failures at minimum five years in two separate clinical studies.^{41,42}
- **Wear resistance:** The Australian Joint Registry data has demonstrated a lower rate of revision due to loosening for highly cross-linked polyethylene compared to conventional polyethylene, indicating a potential long-term benefit of cross-linked polyethylene.²⁶
- **Oxidation resistance:** X3 has demonstrated similar oxidation resistance to virgin polyethylene.⁴³
- One study comparing X3 to conventional polyethylene showed that X3 had a significantly better survival rate among subsets of patients who were younger than 60 years old and/or had a BMI greater than 35.⁴⁴



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