EVOLUTION OF TKR IMPLANTS AND PHILOSOPHIES

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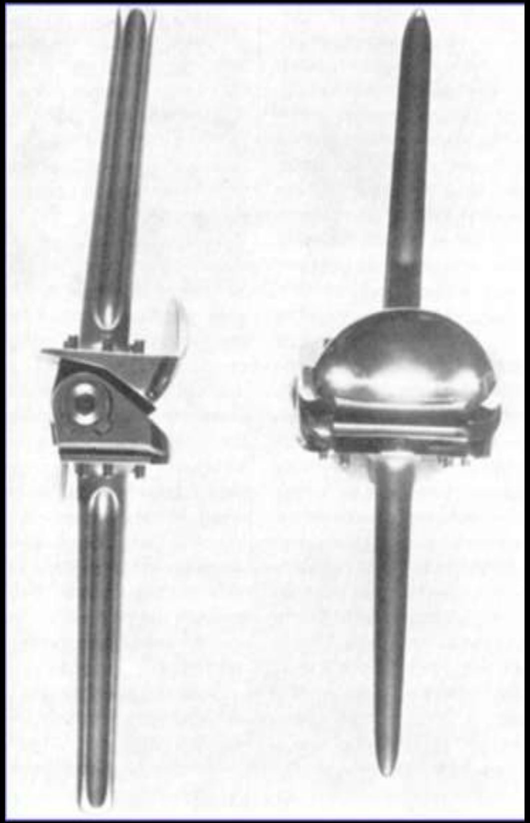
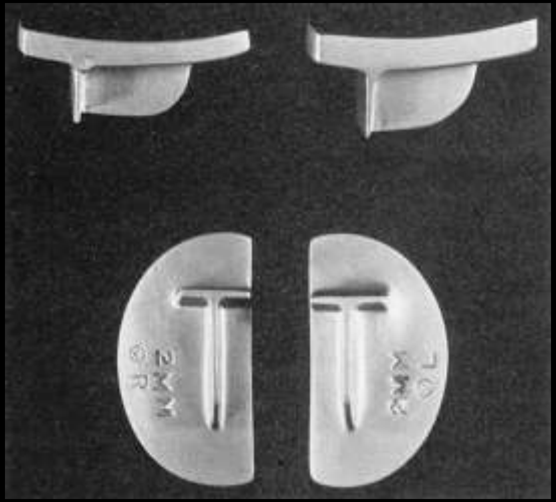
WHAT ARE WE DISCUSSING TODAY?

- CONCEPTS OF DESIGN
- BROAD CLASSIFICATION AND THEIR PROS AND CONS
- NEWER DESIGNS
- UK NJR DATA
- DETAILS OF TWO MOST USED IN IMPLANTS UK
- RESULTS OF SOME OF OLD/STILL USED IMPLANTS AS PER NJR UK

HISTORICAL IMPLANTS



- Walldius Hinge 1950s



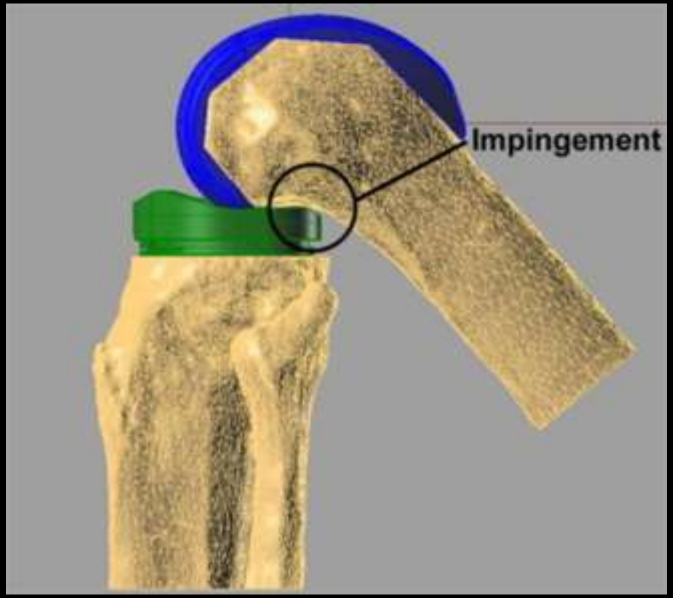
MacIntosh and McKeever 1958

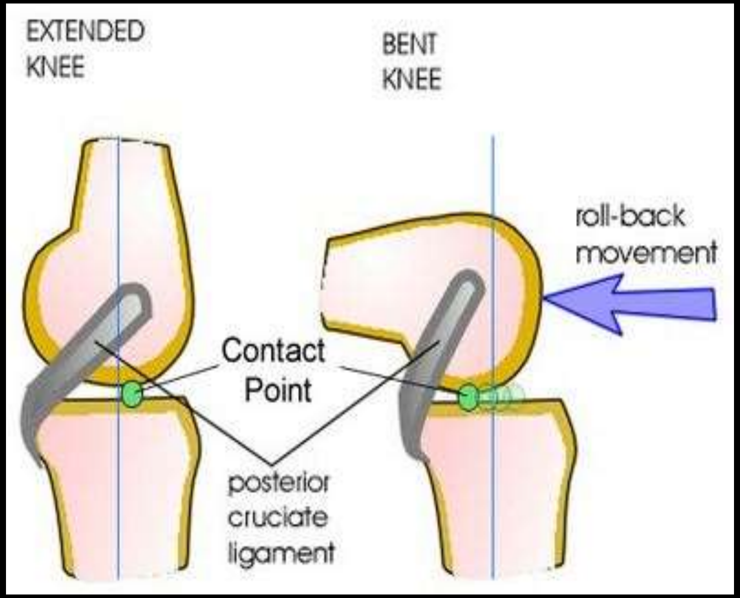
Gunston 1960

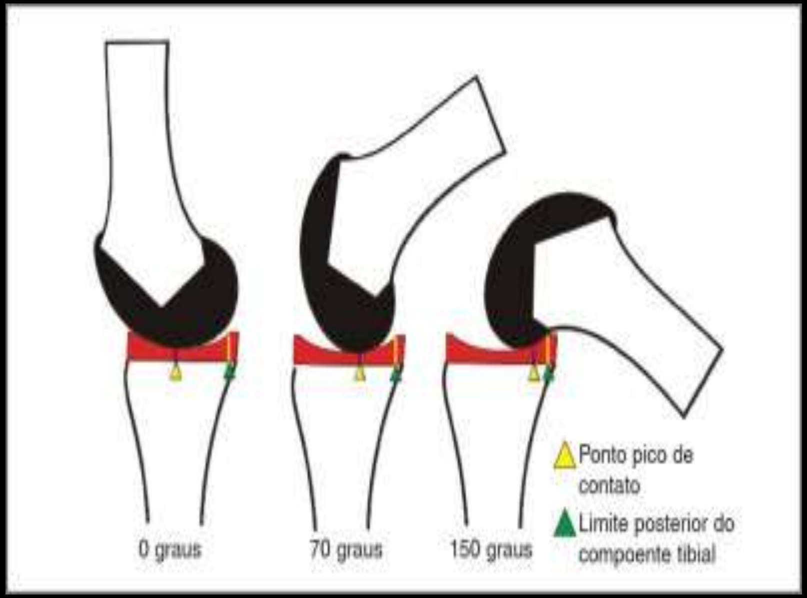
“Total condylar prosthesis 1973

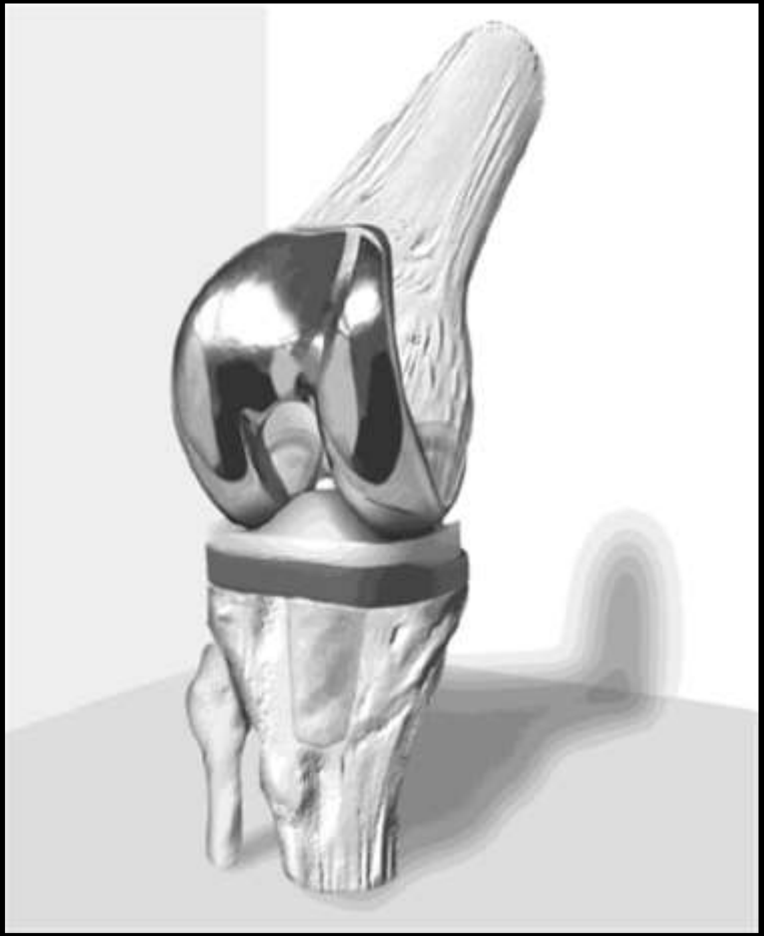
CONCEPTS IN PROSTHETIC DESIGN

- Femoral rollback







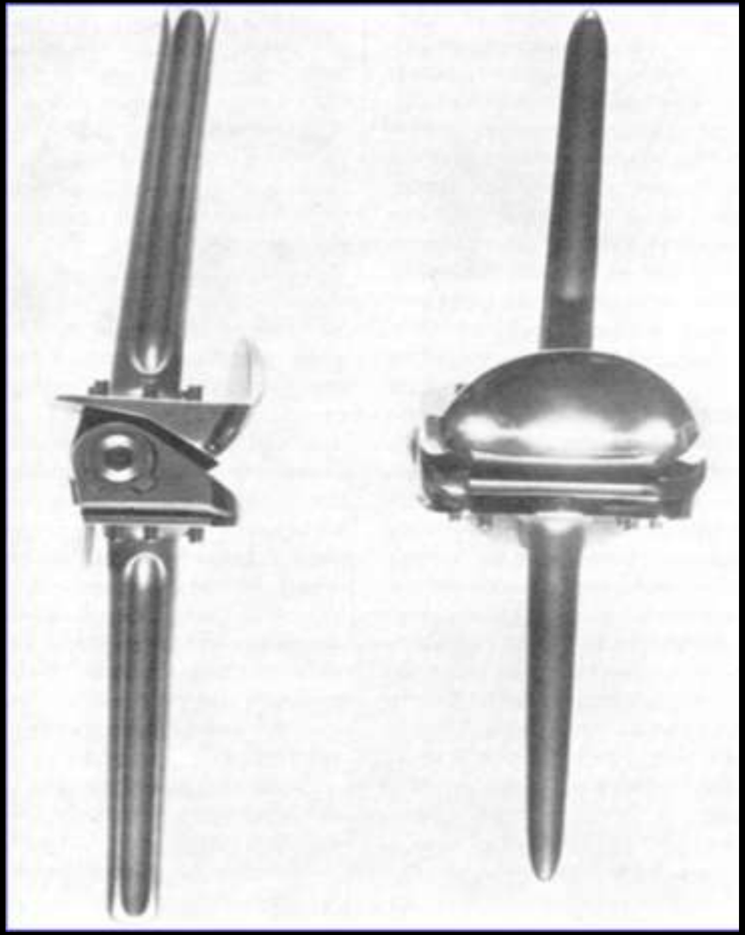


STABILITY

CONSTRAIN

MODULARITY

LOOSENING
WEAR



CONSTRAIN

- Provide Stability
- In Order Of Increased Constrain
    - Cruciate-retaining
    - Posterior-stabilized (Cruciate-substituting)
    - Varus-valgus Constrained (Non-hinged)
    - Rotating-hinge

MODULARITY

- Augment A Standard Prosthesis
- Balance Soft Tissues And/Or Restore Bone Loss
- Customize Implant Intraoperatively
- Problem:
  - Osteolysis
  - Backside Polyethylene Wear

BASIC CLASSIFICATION

- Unconstrained
  - Posterior-cruciate retaining (CR)
  - Posterior-cruciate substituting (PS)
- Constrained
  - Non hinged
  - Hinged
- Fixed versus mobile bearing

CRUCIATE-RETAINING (CR) DESIGN

- Minimally Constrained

- Indications
  - Minimal Bone Loss/ Soft Tissue Laxity, And An Intact PCL
  - Varus Deformity < 10 Degrees
  - Valgus Deformity < 15 Degrees

CRUCIATE-RETAINING (CR) DESIGN

- Advantages
  - No Post-cam Impingement/Dislocation
  - Normal Knee Kinematics
  - Bone Preservation
  - Proprioception
  - Newer Poly-options

- Disadvantages
  - Difficult to balance
  - Tight PCL Leads To Polyethylene Wear
  - Loose PCL May Lead To Flexion Instability And Subluxation

POSTERIOR STABILIZED (PS) DESIGN

- More Constrained
- Increased The Flexion Gap
- Femoral Cam
- Polyethylene More Congruent, Or Deeply "Dished"

POSTERIOR STABILIZED (PS) DESIGN

- Indications
  - Previous Patellectomy
  - Weak Extensor Mechanism
  - Inflammatory Arthritis
  - Deficient Or Absent PCL

POSTERIOR STABILIZED (PS) DESIGN

- Advantages
  - Easier To Balance A Knee With Absent PCL
  - Arguably More Range Of Motion
  - Easier Surgical Exposure

POSTERIOR STABILIZED (PS) DESIGN

- Disadvantages
  - Cam Jump Dislocate
  - Tibial Post Polyethylene Wear
  - Patellar "Clunk Syndrome

CONSTRAINED NONHINGED DESIGN

- Without Axle Connecting Tibial And Femoral Components (Nonhinged)
- Large Tibial Post And Deep Femoral Box Provide
  - Varus/Valgus Stability
  - Rotational Stability

CONSTRAINED NONHINGED DESIGN

- Indications
  - LCL Attenuation Or Deficiency
  - MCL Attenuation Or Deficiency
  - Flexion Gap Laxity
  - Moderate Bone Loss In The Setting Of Neuropathic Arthropathy

CONSTRAINED NONHINGED DESIGN

- Advantages
  - Stability
- Disadvantages
  - More Femoral Bone Resection
  - Aseptic Loosening

CONSTRAINED HINGED DESIGN

- Linked Femoral And Tibial Components (Hinged)
- Tibial Bearing Rotates Around A Yoke On The Tibial Platform (Rotating Hinge)
- Decreases Overall Level Of Constraint

CONSTRAINED HINGED DESIGN

- Indications

  - Global Ligamentous Deficiency

  - Hyperextension Instability

  - Resection For Tumour

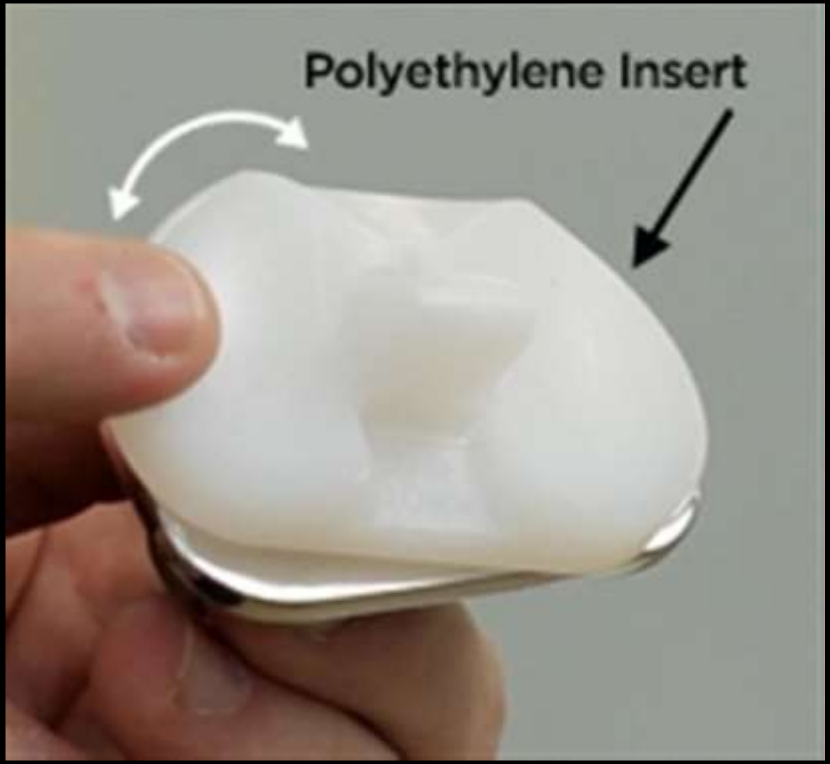
  - Massive Bone Loss

CONSTRAINED HINGED DESIGN

- Advantages
  - Stability
- Disadvantages
  - Aseptic loosening
  - Large bone resection

MOBILE BEARING DESIGN

- Minimally constrained
  - Polyethylene rotate
  - PCL is removed at time of surgery
- Indications
  - Young, active patients (relative indication)



MOBILE BEARING DESIGN

- Advantages
  - Reduces Wear
  - Increased Contact Area
- Disadvantages
  - Bearing Spin-out

ALL-POLYETHYLENE BASE PLATES

- Design
  - Solid Block Of Polyethylene
- Indications
  - No Clear Indications

ALL-POLYETHYLENE BASE PLATES

- Advantages
  - Less Expensive
  - Decreased Osteolysis

- Disadvantages
  - Lose Modular Flexibility

- Outcomes
  - Equivalent Outcomes With Decreased Cost

HIGHLY CONGRUENT LINERS

- Design
  - Medial Compartment Concavity Allows Lateral Compartment To Translate Between Flexion And Extension
  - This Creates A Medial Pivot
- Indications
  - No Clear Indications

HIGHLY CONGRUENT LINERS

- Advantages
  - May Better Create Native Knee Kinematics
- Outcomes
  - Equivalent Outcomes And Survivorship In Short And Mid-term Studies

PATIENT SPECIFIC INSTRUMENTATION

- Design
  - Instrumentation Based On Imaging Specific To Patient's Anatomy
- Indications
  - No Clear Indications At This Time
- Advantages
  - Less Instrumentation To Process Peri-operatively
- Outcomes showed no benefit in
  - Cost Benefit
  - Postoperative TKA Alignment
  - Outcomes Or Patient Satisfaction

WHAT DOES SURGEON WANT

- Work Flawlessly, switch between CR-PS-more constrained
- Perfect Alignment
- Offer Options For Every Surgical Indication
- Satisfy The Surgeon’s Preference
- Greater Simplicity
- Increased Conformity
- Polyethylene Wear Reduction.

IDEAL IMPLANT

- SIMPLE
- LEAST CONSTRAINT
- MOST STABLE
- LEAST WEAR
- LIGAMENT PRESERVATION

NJR UK (NATIONAL JOINT REGISTRY) UK REPORT 2022

Table 3.K1 Number and percentage of primary knee replacements by fixation, constraint and bearing.

Fixation, constraint and bearing type	Number of primary knee operations	Percentage of each constraint type used within each method of fixation	Percentage of all primary knee operations
All types	**1,442,051**		**100.0**
Total knee replacement			
All cemented	**1,206,605**		**83.7**
unconstrained, fixed	832,844	69.0	57.8
unconstrained, mobile	41,741	3.5	2.9
posterior-stabilised, fixed	284,858	23.6	19.8
posterior-stabilised, mobile	13,486	1.1	0.9
constrained condylar	12,225	1.0	0.8
monobloc polyethylene tibia	19,151	1.6	1.3
pre-assembled/hinged/linked	2,300	0.2	0.2
All uncemented	**48,781**		**3.4**
unconstrained, fixed	19,115	39.2	1.3
unconstrained, mobile	25,860	53.0	1.8
posterior-stabilised, fixed	3,510	7.2	0.2
other constraints	296	0.6	<0.1
All hybrid	**10,116**		**0.7**
unconstrained, fixed	6,593	65.2	0.5
unconstrained, mobile	2,184	21.6	0.2
posterior-stabilised, fixed	923	9.1	0.1
other constraints	416	4.1	<0.1
Unicompartmental knee replacement			
All unicondylar, cemented	**103,385**		**7.2**
fixed	46,346	44.8	3.2
mobile	50,506	48.9	3.5
monobloc polyethylene tibia	6,533	6.3	0.5
All unicondylar, uncemented/hybrid	**33,508**		**2.3**
fixed	1,421	4.2	0.1
mobile	31,611	94.3	2.2
monobloc polyethylene tibia	476	1.4	<0.1
Patellofemoral	**16,476**		**1.1**
Multicompartmental	**622**		**<0.1**
Unconfirmed	**22,558**		**1.6**

Fixation, constraint and bearing type
All types
Total knee replacement
All cemented
unconstrained, fixed
unconstrained, mobile
posterior-stabilised, fixed
posterior-stabilised, mobile
constrained condylar
monobloc polyethylene tibia
pre-assembled/hinged/linked

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

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PFC SIGMA

DEPUY SYNTHES

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PFC Sigma Bicondylar Knee[Fem] M.B.T.[Tib]	17,483	65 (58 to 72)	47	0.63 (0.52-0.76)	2.00 (1.80-2.22)	2.77 (2.53-3.03)	3.93 (3.64-4.26)	4.99 (4.57-5.45)	*5.06 (4.62-5.55)*
PFC Sigma Bicondylar Knee[Fem] PFC Bicondylar[Tib]	177,771	70 (64 to 76)	43	0.39 (0.36-0.42)	1.27 (1.21-1.32)	1.75 (1.68-1.81)	2.47 (2.39-2.56)	3.20 (3.09-3.32)	3.69 (3.47-3.93)
PFC Sigma Bicondylar Knee[Fem] PFC Sigma Bicondylar[Tib]	201,837	70 (64 to 77)	42	0.37 (0.35-0.40)	1.38 (1.33-1.44)	1.93 (1.87-2.00)	2.60 (2.52-2.69)	*2.99 (2.80-3.19)*	

Deep And Extended Trochlear Groove

Matching Single-radius Dome Patella

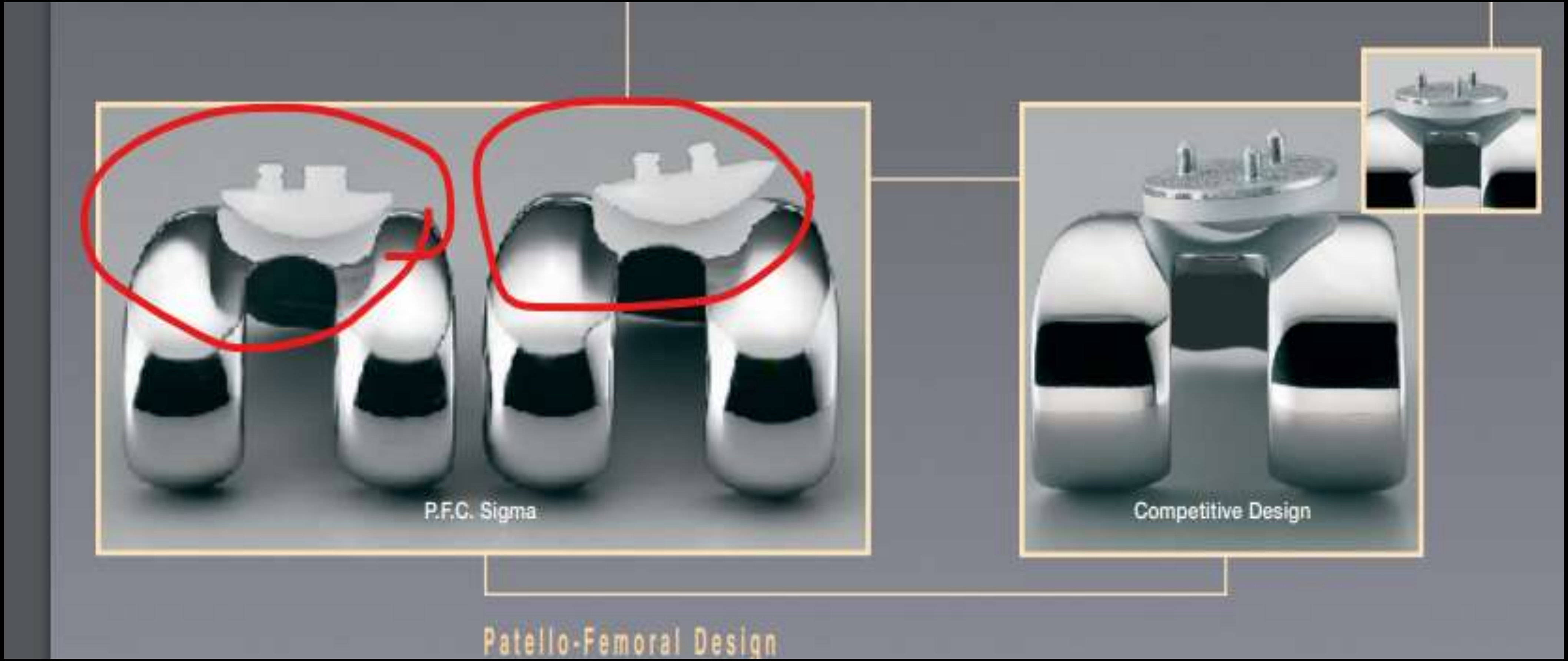
Maintain Maximum Contact Up To And Beyond 90° Flexion

Condylar Geometry Is Blended Into The Trochlear Groove

Patella meet Congruently With The Femoral Component Both In Perfect Alignment And Patellar Tilt.

The Patello-femoral Design Eliminates The Alignment Sensitivity

Patella Avoids The Point Contact

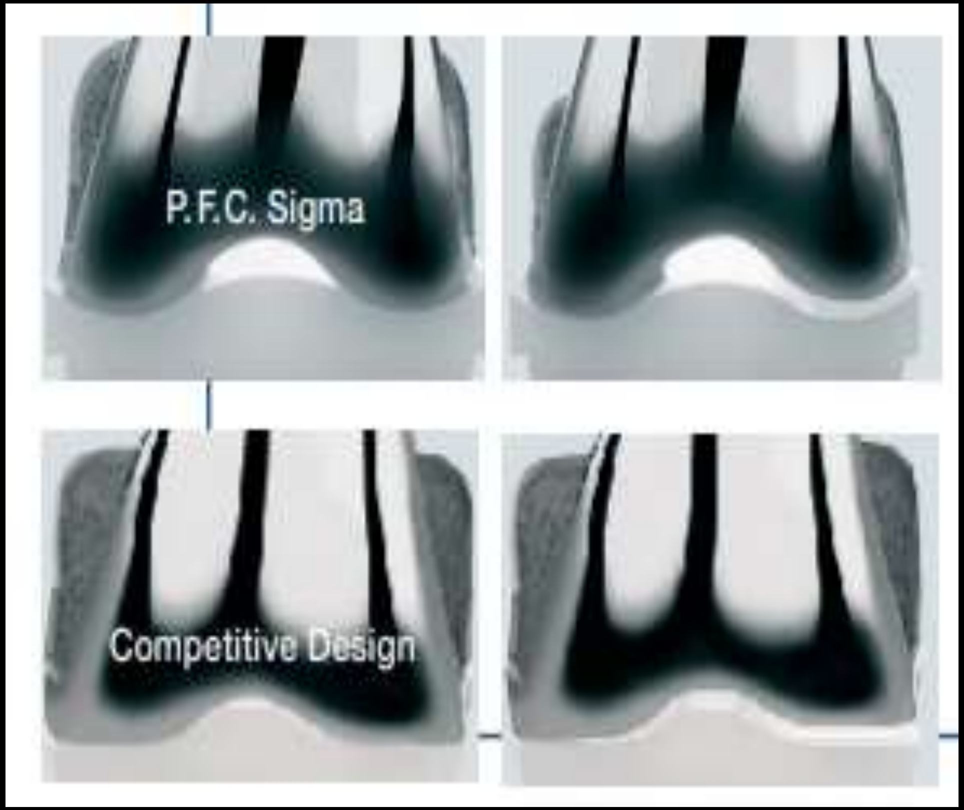


Coronal Geometry:

Rounded In The Coronal Plane

Maximizing Contact Area

Reducing Peak Stresses On The Polyethylene Insert



No Thrusts So No Edge Loading

POSTERIOR LIPPED

The Broad Sagittal Radius
Posterior Lip

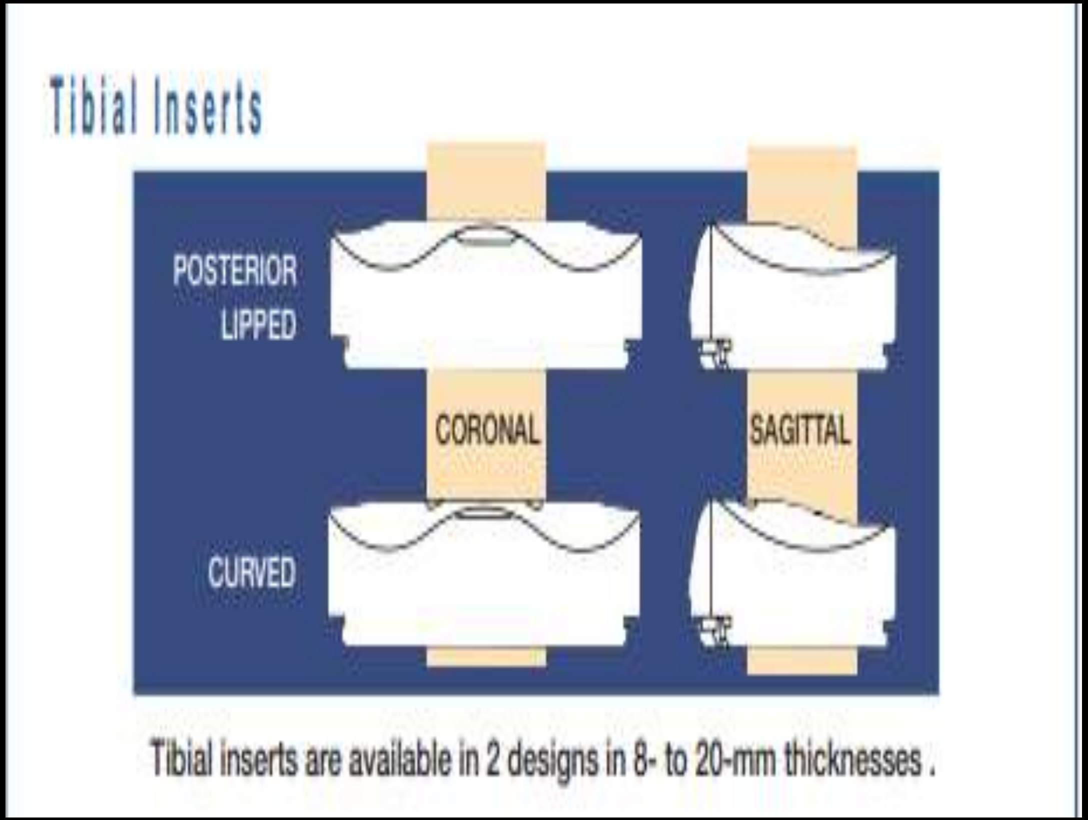
The Rounded Coronal shape

Curved A Single Sagittal Radius

Provides Greater Conformity For Anterior-posterior Stability

Peak Stresses

Below The Yield Strength Of Polyethylene



Gentle radius of curvature of patella

Deep single-radius trochlear groove

Enables the patella to sit deeply at high flexion

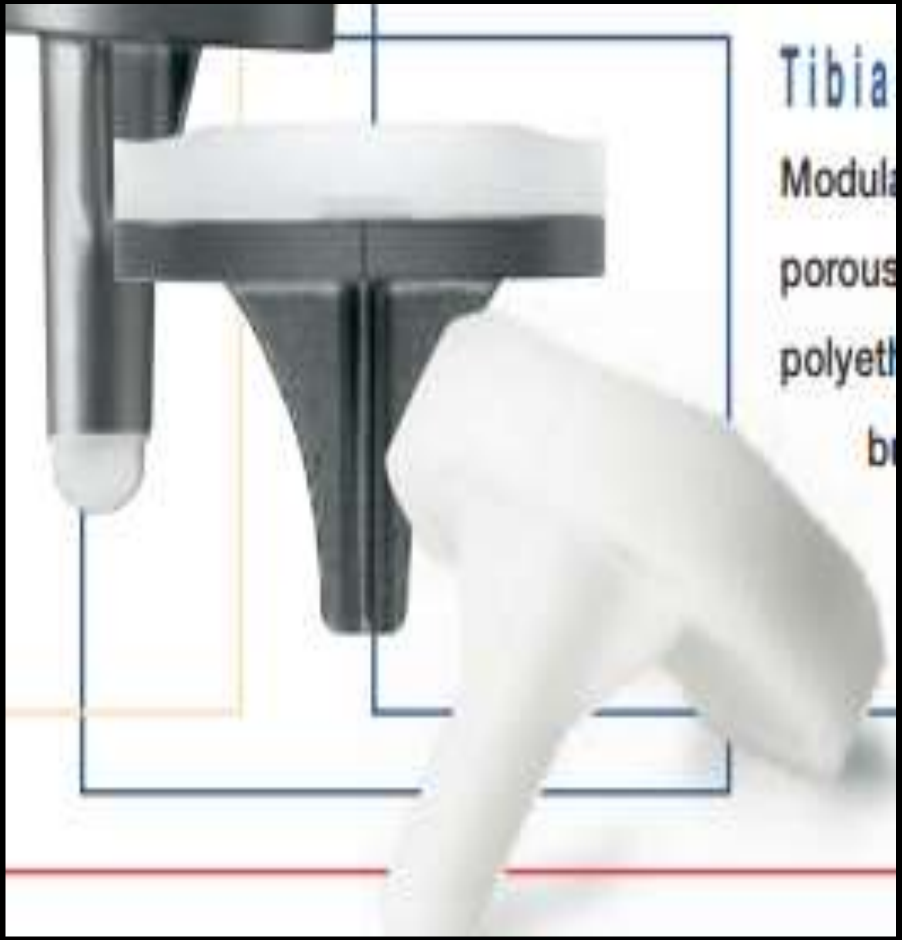
High anterior flange

keep the patella in constant contact with the femoral component.

Tibial Trays

Modular

keel tibial trays porous and nonporous

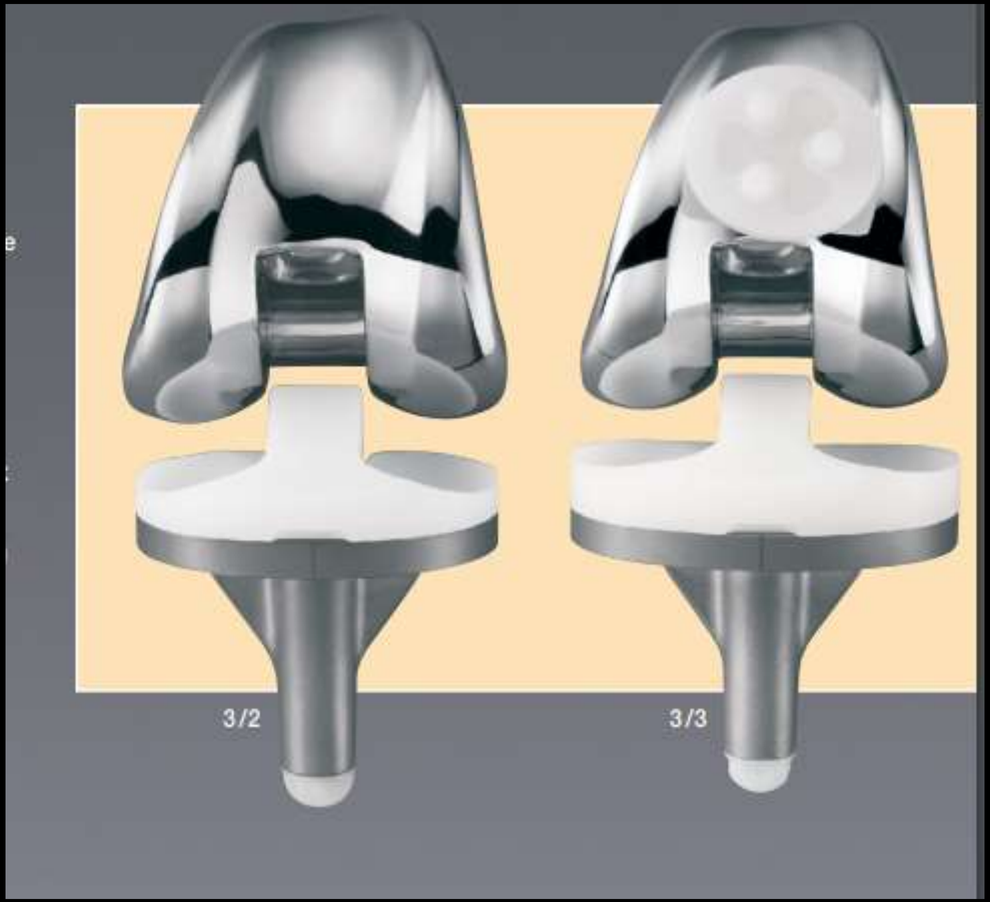


These titanium trays

buffers medial- lateral rotation and anterior-posterior liftoff.

With the ability to up- and downsize

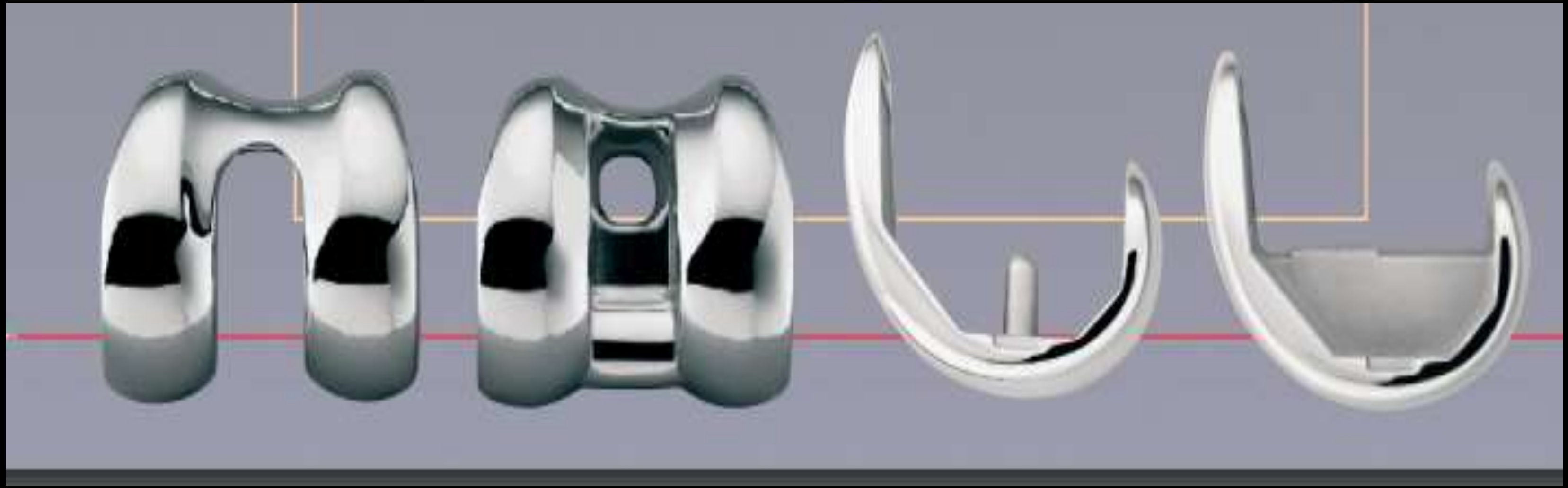
**A 3-size spread
(one-up and one-down)**



Easy Transition Between Cruciate-retaining And Cruciate-substituting

Femoral Components Coronal Geometry: Increased Condylar Conformity And Providing High Contact Area, Low Peak Stresses, And Protection Against Edge Loading

Sagittal Shape For Ease Of Patello-femoral Tracking And Congruent Patellar Contact Under Loading Conditions.



The Patented Cam And Spine Design

Cam: Shear Forces Are Consistently Transferred Into Compression.


P.F.C. Sigma PS Femoral Component at 0°, 80°, and 90°

Two types of cruciate-substituting inserts

Intraoperative choices for addressing soft-tissue deficiency and instability.

Posterior stabilized insert is used for primary cruciate substitution

Stabilized plus insert provides varus-valgus support and tighter medial-lateral rotation when additional collateral stability is indicated

ferred into compression. This differs from designs in which a posteriorly placed spine may make the component vulnerable to rapid rollback and posterior articulation. The P.F.C. Sigma liftoff value at 90° is 16.3 mm.

* U.S. Patent 4298992, owned by the Hospital for Special Surgery (H.S.S.), New York City.

Modularity

Primary cruciate-substituting prostheses allow surgeons to utilize complete stem and augment options without changing prostheses or resecting more bone for revision procedures.

DePuy
a Johnson & Johnson company

REVISION

Customizing the Implant to the Patient

The P.F.C. Sigma TC3 enables surgeons to address the complex needs of revision surgery with modular components that are easily customized to fit a variety of patient indications. The TC3 femoral components and tibial inserts provide a high level of constraint for stability in knees with collateral soft-tissue deficiencies.

A complete matrix of mechanically attached distal and posterior augments allows surgeons to properly reestablish the joint line.

Femoral Components

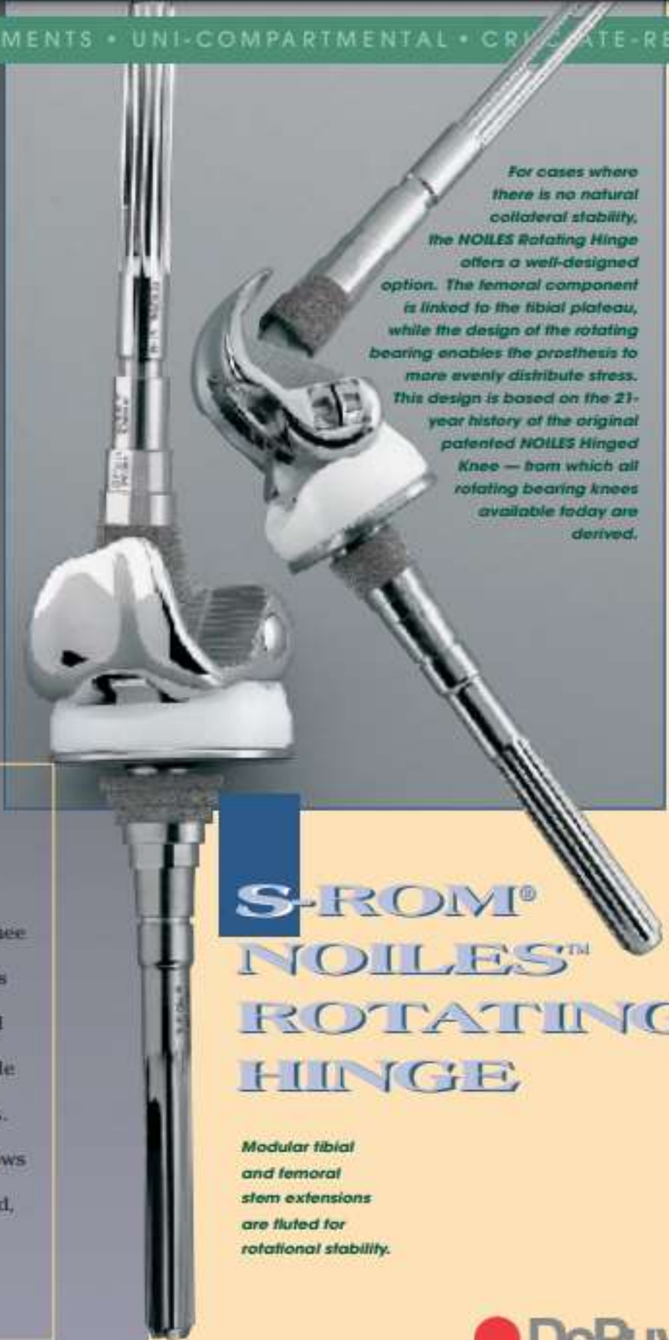
TC3 femoral components have the same coronal, sagittal, and trochlear-groove geometries found in all P.F.C. Sigma cruciate-retaining and -substituting designs. They also have the same patented cam and spine mechanism used in the cruciate-substituting component. All TC3 femoral components are asymmetrical for proper anatomic fit and can be mixed and matched with tibial inserts one size up or down.

TING • CRUCIATE-SUBSTITUTING • ON • SPECIALIST® 2 INSTRUMENTS • UNI-COMPARTMENTAL • CR ATE-RETAIN

A wide range of femoral and tibial stems, along with mechanically attached or cemented tibial wedges, allows the surgeon to meet the challenge of any bony defect.

An Option for the Exceptional Revision

Ultimate stability and management of bony defects are made possible with the S-ROM NOILES Rotating Hinge Knee System. Modular sleeves and stems in a range of sizes provide optimal fit and fill for management of a wide range of metaphyseal deficiencies. The system's rotating bearing allows stress to be more evenly distributed, helping to protect the cement-prosthesis interface.



For cases where there is no natural collateral stability, the NOILES Rotating Hinge offers a well-designed option. The femoral component is linked to the tibial plateau, while the design of the rotating bearing enables the prosthesis to more evenly distribute stress. This design is based on the 21-year history of the original patented NOILES Hinged Knee — from which all rotating bearing knees available today are derived.

S-ROM® NOILES™ ROTATING HINGE

Modular tibial and femoral stem extensions are fluted for rotational stability.

DePuy
a Johnson & Johnson company

NEXGEN
ZIMMER BIOMET

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

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Nexgen[Fem:Tib]	183,105	70 (64 to 76)	42	0.38 (0.35-0.41)	1.26 (1.20-1.31)	1.97 (1.90-2.04)	3.38 (3.27-3.49)	4.52 (4.33-4.71)	5.32 (4.80-5.90)

NexGen Knee replacement: affected patients should be offered additional follow up, DSI/2023/003

The National Joint Registry (NJR) has identified that both the NexGen® Stemmed Option Tibial Components, when paired with either the Legacy® Posterior Stabilized (LPS) Flex Option Femoral or the LPS Flex Gender Solutions Femoral (GSF) Option Femoral, had a higher overall revision rate and a higher revision rate for aseptic tibial loosening compared to the average revision rate of all other total knee replacements in the UK NJR.

TRITHLON

STRYKER

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Triathlon[Fem:Tib]	162,424	70 (63 to 76)	43	0.48 (0.45-0.52)	1.42 (1.36-1.49)	1.98 (1.91-2.06)	2.89 (2.77-3.03)	3.79 (3.42-4.19)	

Experience the difference
of our circular,
single-radius design.

Ligament Balance

While femoral components of most knee systems create multiple turning radii during movement, the Stryker Triathlon system is built around a circular, Single Radius design. It's rotation is designed to mimic natural knee kinematics, allow for constant ligament balance, and offer enhanced stability throughout the active range of motion. [1-3] Knee replacement has finally come full circle.

Shorter Posterior Condyle

The shorter posterior condyles facilitate the relaxation of the soft tissues to enable deep flexion[6]

Flared Posterior Condyles

Designed to accommodate 20 degrees of internal/external rotation throughout the range of motion[7]


Rotary Arc
Precision machined surface facilitates internal/external rotation[6]

Anatomic Patellofemoral Track

Designed with a deepened trochlear groove to help relax the extensor mechanism, enable deeper flexion, and reduce contact stresses exerted across the patella[8]

Triathlon is designed to allow for +/- 10 degrees of rotation in hyperextension and extension. In these early

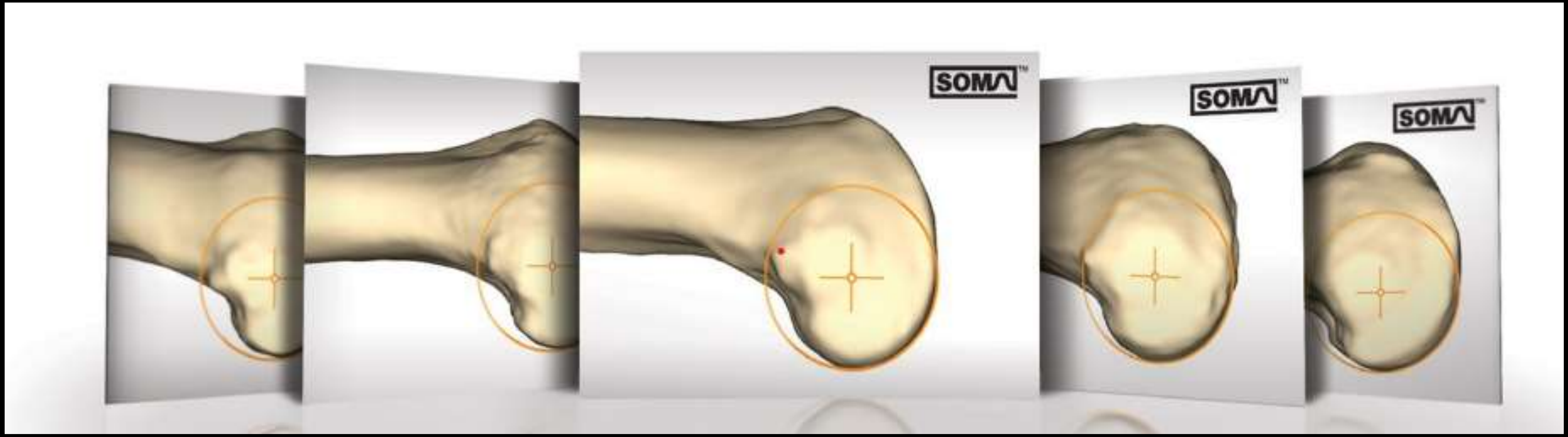
degrees of motion, Triathlon has demonstrated less post impingement and torque forces than other designs.44

Stryker's single radius knee is designed to replace the way the knee moves

Traditionally thought shape of the posterior condyles oval in shape.

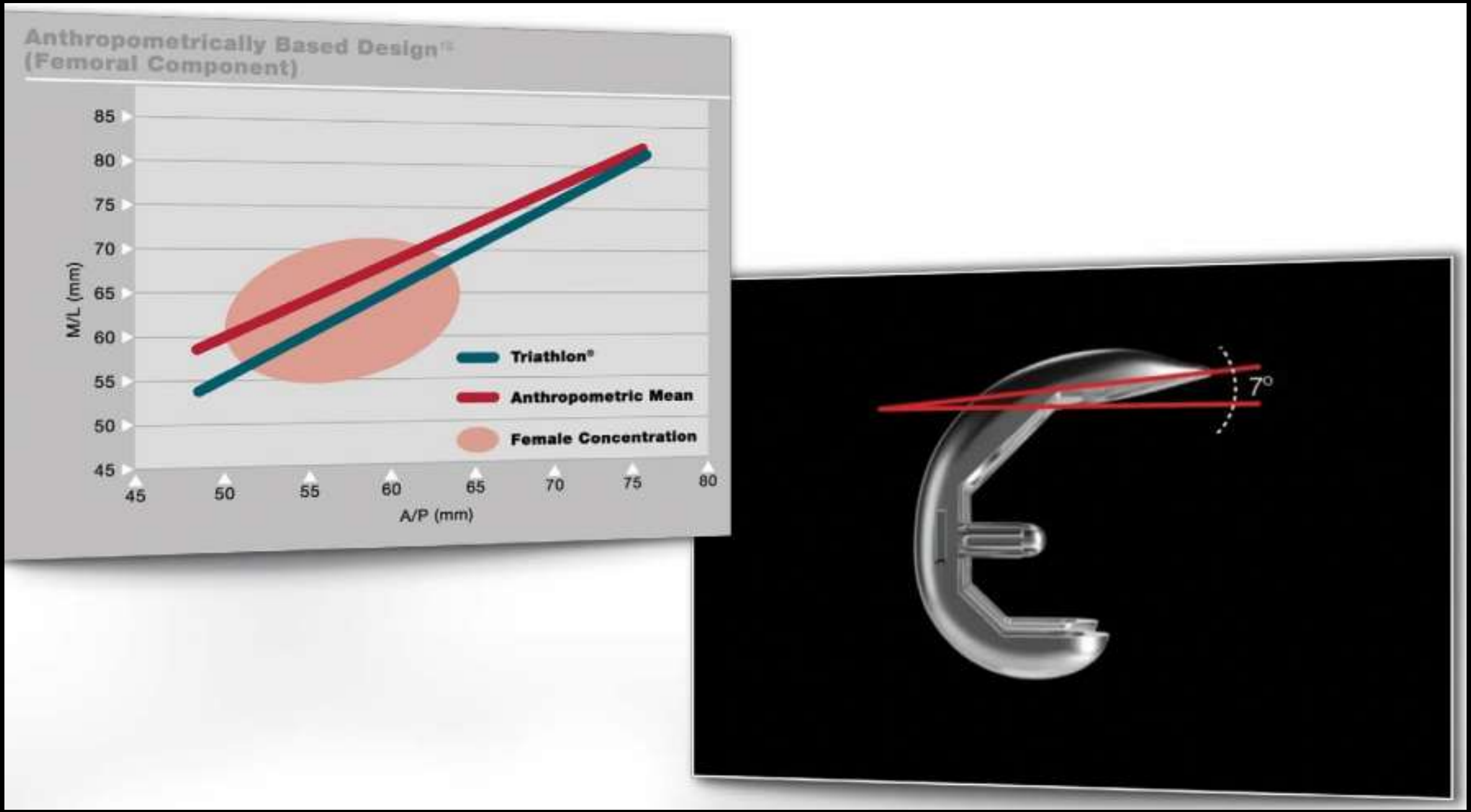
Modern research :

> **Along the transepicondylar axis, which revealed that the shapes of the posterior condyles were circular.**

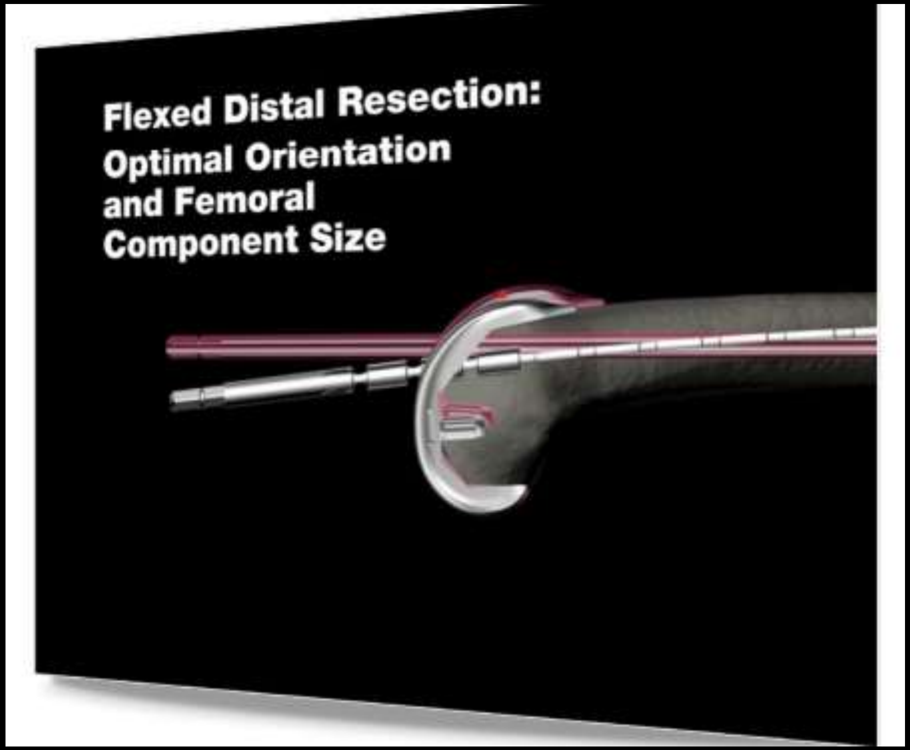


- **Improved Interplay Between Implant Geometry And Anatomic Structure For Women And Men. The Unique 7-degree Anterior Flange Design**

  Provide The Flexibility To Downsize The Femoral Component While Avoiding The Incidence Of Notching.



Triathlon also has a unique instrument that works with the patient's individual anterior femoral bow. Anterior bow of the femur varies widely.31 The Triathlon FlexRod bends to avoid making distal femoral resection in extension due to a patient's anterior femoral bow. In a retrospective study, by reducing the likelihood of making the distal resection in extension the FlexRod has been shown to allow more downsizing than the rigid rod.12 In a separate prospective study, patients whose procedure included the FlexRod had greater range of motion and higher KSS scores.12



OTHER IMPLANTS

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Genesis II Oxinium[Fem] Genesis II[Tib]	11,829	59 (54 to 65)	40	0.57 (0.45-0.73)	2.32 (2.06-2.62)	3.43 (3.09-3.80)	5.96 (5.44-6.53)	7.39 (6.65-8.21)	
Genesis II[Fem:Tib]	90,539	71 (65 to 77)	42	0.47 (0.43-0.52)	1.46 (1.38-1.55)	2.01 (1.91-2.11)	2.97 (2.83-3.12)	3.42 (3.20-3.64)	*3.56 (3.27-3.87)*

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Brand[1]	N	Median (IQR) age at primary	Male (%)	Time since primary: 1 year	3 years	5 years	10 years	15 years	18 years
All total knee replacements	1,265,502	70 (63 to 76)	43	0.43 (0.42-0.44)	1.47 (1.45-1.49)	2.10 (2.07-2.13)	3.19 (3.15-3.23)	4.31 (4.24-4.37)	5.12 (4.96-5.29)
Vanguard[Fem:Tib]	88,536	70 (63 to 76)	42	0.40 (0.36-0.44)	1.40 (1.32-1.48)	1.99 (1.89-2.09)	2.92 (2.75-3.10)		
Vanguard[Fem] Maxim[Tib]	2,368	70 (62 to 76)	41	0.43 (0.23-0.80)	1.83 (1.34-2.52)	3.06 (2.37-3.95)	4.58 (3.68-5.69)	*5.17 (4.15-6.43)*	

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Brand[1]	N	Median (IQR) age at primary	Male (%)	Time since primary: 1 year	3 years	5 years	10 years	15 years	18 years
All total knee replacements	1,265,502	70 (63 to 76)	43	0.43 (0.42-0.44)	1.47 (1.45-1.49)	2.10 (2.07-2.13)	3.19 (3.15-3.23)	4.31 (4.24-4.37)	5.12 (4.96-5.29)
Attune[Fem] Attune FB[Tib]	33,769	70 (62 to 76)	44	0.39 (0.32-0.46)	1.44 (1.31-1.59)	2.06 (1.88-2.27)			
Attune[Fem] Attune RP[Tib]	5,770	70 (62 to 76)	44	0.26 (0.16-0.45)	0.92 (0.67-1.25)	1.37 (1.03-1.83)			
Columbus Cemented[Fem] Columbus CR/PS[Tib]	16,684	70 (64 to 77)	42	0.44 (0.35-0.56)	1.43 (1.25-1.63)	1.99 (1.77-2.23)	2.99 (2.65-3.38)	*3.69 (3.15-4.32)*	

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

				Time since primary					
Brand[1]	N	Median (IQR) age at primary	Male (%)	1 year	3 years	5 years	10 years	15 years	18 years
All total knee replacements	**1,265,502**	**70 (63 to 76)**	**43**	**0.43 (0.42-0.44)**	**1.47 (1.45-1.49)**	**2.10 (2.07-2.13)**	**3.19 (3.15-3.23)**	**4.31 (4.24-4.37)**	**5.12 (4.96-5.29)**
Scorpio NRG[Fem:Tib]	14,111	70 (64 to 77)	42	0.41 (0.32-0.53)	1.58 (1.39-1.81)	2.41 (2.16-2.68)	3.63 (3.31-3.99)	*4.30 (3.85-4.81)*	
Scorpio[Fem:Tib]	3,272	68 (61 to 75)	45	0.37 (0.21-0.65)	2.16 (1.71-2.73)	3.11 (2.56-3.78)	4.65 (3.95-5.47)	5.96 (5.06-7.02)	*7.97 (5.48-11.52)*
Scorpio[Fem] Scorpio NRG[Tib]	21,808	71 (64 to 77)	42	0.44 (0.36-0.54)	1.82 (1.65-2.01)	2.61 (2.41-2.84)	4.00 (3.74-4.28)	5.14 (4.81-5.49)	*5.59 (5.11-6.12)*

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Brand[1]	N	Median (IQR) age at primary	Male (%)	Time since primary					
				1 year	3 years	5 years	10 years	15 years	18 years
All total knee replacements	**1,265,502**	**70 (63 to 76)**	**43**	**0.43 (0.42-0.44)**	**1.47 (1.45-1.49)**	**2.10 (2.07-2.13)**	**3.19 (3.15-3.23)**	**4.31 (4.24-4.37)**	**5.12 (4.96-5.29)**
LCS Complete[Fem] M.B.T.[Tib]	29,926	70 (63 to 76)	44	0.42 (0.36-0.51)	1.67 (1.53-1.83)	2.47 (2.29-2.66)	3.61 (3.37-3.86)	4.39 (4.07-4.73)	

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Brand[1]	N	Median (IQR) age at primary	Male (%)	Time since primary: 1 year	3 years	5 years	10 years	15 years	18 years
All total knee replacements	1,265,502	70 (63 to 76)	43	0.43 (0.42-0.44)	1.47 (1.45-1.49)	2.10 (2.07-2.13)	3.19 (3.15-3.23)	4.31 (4.24-4.37)	5.12 (4.96-5.29)
AGC[Fem]AGC V2[Tib]	28,950	71 (64 to 77)	42	0.30 (0.24-0.37)	1.58 (1.44-1.73)	2.22 (2.05-2.40)	3.52 (3.29-3.76)	5.31 (4.90-5.77)	*6.78 (5.88-7.80)*

Table 3.K7 (a) KM estimates of cumulative revision (95% CI) by total knee replacement brands. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Brand[1]	N	Median (IQR) age at primary	Male (%)	Time since primary					
				1 year	3 years	5 years	10 years	15 years	18 years
All total knee replacements	1,265,502	70 (63 to 76)	43	0.43 (0.42-0.44)	1.47 (1.45-1.49)	2.10 (2.07-2.13)	3.19 (3.15-3.23)	4.31 (4.24-4.37)	5.12 (4.96-5.29)
Optetrak CR[Fem] Optetrak[Tib]	1,641	70 (63 to 76)	43	0.86 (0.51-1.45)	3.44 (2.65-4.46)	4.89 (3.93-6.08)	8.17 (6.84-9.74)	*10.72 (8.75-13.10)*	

THANKS AND GN