

Let's Talk  
**Science...**

The Science of:

▶ **Motion**<sup>13</sup>

▶ **Fit**<sup>6</sup>

▶ **Wear**<sup>1</sup>

**Triathlon**<sup>®</sup>  
Knee System

# The Science of Increased Motion™

High flexion knee system designed for mobility with stability through 150 degrees of motion.



- Flared Posterior Condyles**
- Open design accommodates 20 degrees of internal/external rotation throughout the range of motion.<sup>7</sup>

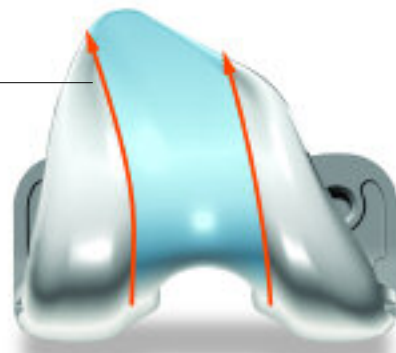
- Rotary Arc Insert**
- Precision-machined surface facilitates internal/external rotation

**Anatomic Radius (10° – 110°)**

- Designed to maintain collateral ligament stability throughout the range of motion.<sup>8</sup>
- Centered at the transepicondylar axis - the optimal flexion axis of the knee.<sup>9</sup>

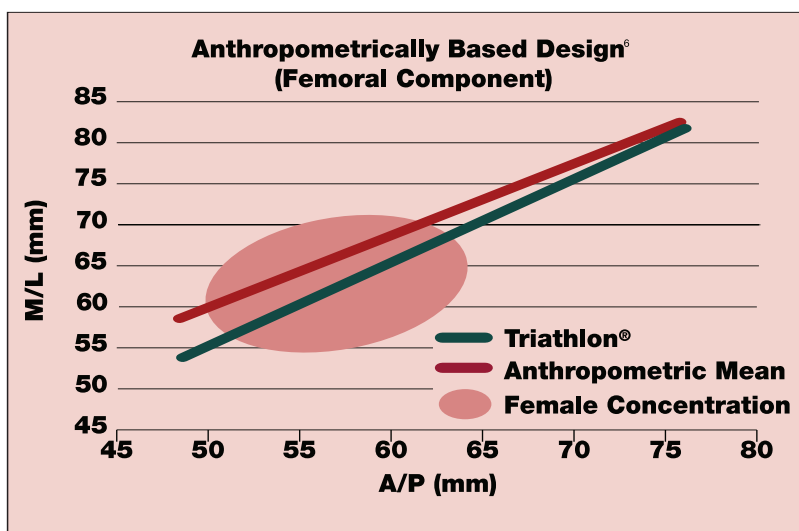
**Anatomic Patellofemoral Track**

- The Triathlon® Knee patellofemoral track shares the same design as preceding Stryker® total knee systems, bringing over a decade of excellent clinical performance and the industry's lowest revision rate (0.3%)<sup>10</sup> to date to this knee system.



# The Science of Better Fit™

Designed with a wide range of sizing options, based on the anatomical differences of men and women.⁶

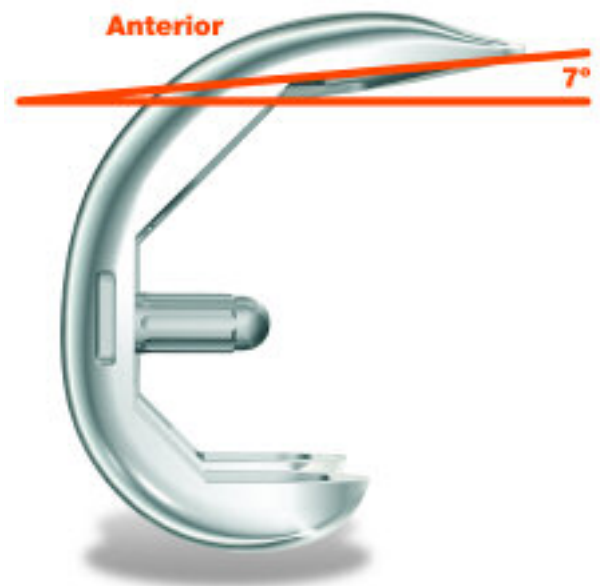


The Triathlon® Knee System addresses smaller anatomies, often found in female patients, heavily concentrated in the region shown, while still accommodating larger male patients.

- Broad range of size offerings are based on an anthropometric measurement study<sup>6</sup> for improved interplay between implant geometry and anatomic structure for women and men.
- The Triathlon® design incorporates a variable aspect ratio to adequately fit the female anatomy while still accommodating the male population.<sup>6</sup>
- The many design aspects of the implant accommodates surgical realities.

## 7-Degree Anterior Flange

- The unique 7-degree anterior flange design of the Triathlon® Knee System is designed to provide the flexibility to downsize the femoral component while avoiding the incidence of notching. This feature culminates in the potential to provide patients with a more customized fit.



# The Science of Reduced Wear™

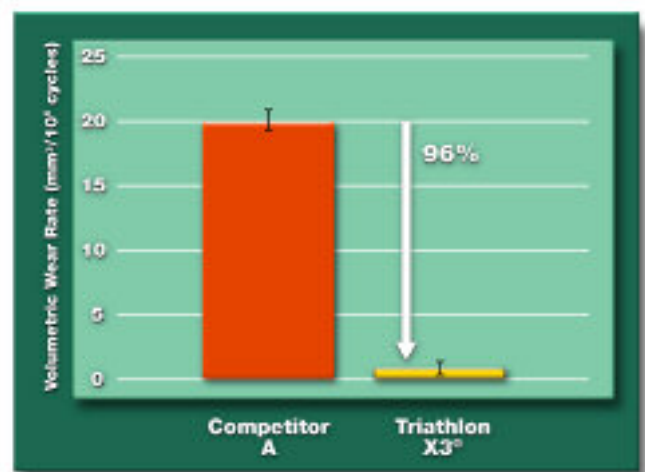
High performance through improved design kinematics combined with X3® Advanced Bearing Technology.<sup>1</sup>

**The Triathlon® Knee System is designed to reduce rotational stresses, increase overall contact area, and minimize backside wear.**

- Through the Rotary Arc design, anatomic radius, and flared posterior condyles, the Triathlon® Knee System balances conformity with constraint to mimic natural knee kinematics and the potential for enhanced wear properties.<sup>2,3,7</sup>

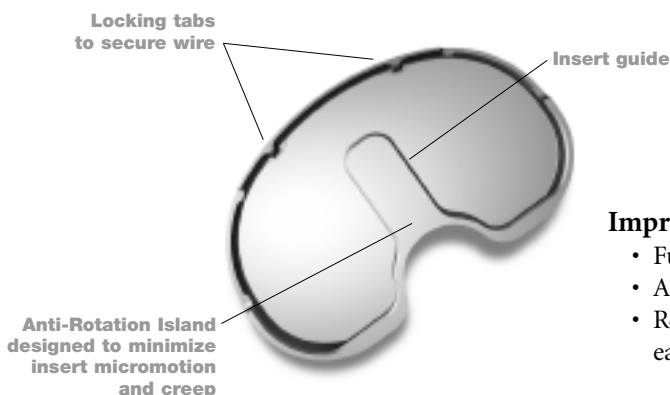


## Wear Test Results: Triathlon® Knee System with X3® versus Competitive Premium Bearing Technology<sup>1</sup>



### X3® Advanced Bearing Technology

- Structural Contact Fatigue Strength better than conventional polyethylene<sup>11</sup>
- Improved Wear Performance<sup>2,3</sup>
  - Oxidation Resistance<sup>4,5</sup>  
Same as virgin polyethylene



### Improved Locking Mechanism Design

- Full periphery locking rim and locking wire.
- Anti rotation island.
- Reduce micromotion and promote ease of insertion.<sup>12</sup>

**The Triathlon® Knee System is designed to meet patients' expectations for Lifestyle Recovery™. The intuitive and evolutionary design is predicated on the worldwide clinical success of millions of Stryker knee implantations. The Triathlon® Knee System is designed to provide patients with increased motion , better fit and reduced wear.**

**References:**

1. Stryker Orthopaedics Test Report: RD-06-013.
2. Stryker Orthopaedics Triathlon<sup>®</sup> CR Tibial Inserts made from X3<sup>®</sup> UHMWPE, 5530-G-409 show a 68% reduction in volumetric wear rate versus the same insert fabricated from N<sub>2</sub> Vac gamma sterilized UHMWPE, 5530-P-409. The insert tested was Size 4, 9 mm thick. Testing was conducted under multiaxial knee simulator (multi-station MTS knee joint simulator [a]) for five million cycles using appropriate size CoCr counterfaces, a specific type of diluted calf serum lubricant and the motion and loading conditions, representing normal walking, outlined in ISO/DIS 14243-3. Volumetric wear rates were  $17.7 \pm 2.2 \text{ mm}^3/10^6 \text{ cycles}$  for standard polyethylene inserts and  $5.7 \pm 1.5 \text{ mm}^3/10^6 \text{ cycles}$  for test samples. Test inserts were exposed to a gas plasma sterilization process. In vitro knee wear simulator tests have not been shown to quantitatively predict clinical wear performance.
  - [a] A. Essner, A. Wang, C. Stark and J. H. Dumbleton, "A simulator for the evaluation of total knee replacement wear," 5th World Biomaterials Congress, Toronto, Canada, May, 1996, pg 580.
3. Stryker Orthopaedics Triathlon<sup>®</sup> PS Tibial Inserts made of X3<sup>®</sup> UHMWPE, 5532-G-409 show a 64% reduction in volumetric wear rate versus the same insert fabricated from N<sub>2</sub> Vac gamma sterilized UHMWPE, 5532-P-409. The insert tested was Size 4, 9 mm thick. Testing was conducted under multiaxial knee simulator (multi-station MTS knee joint simulator) for five million cycles using a size 7 CoCr counterfaces, a specific type of diluted calf serum lubricant and literature or fluoroscopy based motion and loading conditions representing stair climbing [b,c]. Volumetric wear rates were  $3.6 \pm 0.61 \text{ mm}^3/10^6 \text{ cycles}$  for standard polyethylene inserts and were  $1.3 \pm 0.44 \text{ mm}^3/10^6 \text{ cycles}$  for test samples. Test inserts were exposed to a gas plasma sterilization process. In vitro knee wear simulator tests have not been shown to quantitatively predict clinical wear performance.
  - [b] R. Rieneer, M. Rabuffetti and C. Frigo, "Stair ascent and descent at different inclinations," Gait and Posture 15: 2002, pp. 32-44.
  - [c] JB. Morrison, "Function of the knee joint in various activities," Bio-medical Engineering, 4: 1969, pp. 573-580.
4. X3<sup>®</sup> UHMWPE maintains mechanical properties after accelerated oxidative aging. No statistical difference was found for Tensile Yield Strength, Ultimate Tensile Strength and Elongation as measured per ASTM D638 before and after exposure to ASTM F2003 accelerated aging (5 Atmospheres (ATM) of oxygen at 70°C for 14 days). Tensile Yield Strength was  $23.5 \pm 0.3 \text{ MPa}$  and  $23.6 \pm 0.2 \text{ MPa}$ , Ultimate Tensile Strength was  $56.7 \pm 2.1 \text{ MPa}$  and  $56.3 \pm 2.3 \text{ MPa}$ , and Elongation was  $267 \pm 7\%$  and  $266 \pm 9\%$  before and after accelerated oxidative aging, respectively.
5. X3<sup>™</sup> UHMWPE resists the effects of oxidation. No statistical difference was found for Tensile Yield Strength, Ultimate Tensile Strength, Elongation, Crystallinity and Density as measured per ASTM D638, D3417 and D1505 before and after ASTM F2003 accelerated aging (5 ATM of oxygen at 70°C for 14 days). Tensile Yield Strength was  $23.5 \pm 0.3 \text{ MPa}$  and  $23.6 \pm 0.2 \text{ MPa}$ , Ultimate Tensile Strength was  $56.7 \pm 2.1 \text{ MPa}$  and  $56.3 \pm 2.3 \text{ MPa}$ , Elongation was  $267 \pm 7\%$  and  $266 \pm 9\%$ , Crystallinity was  $61.7 \pm 0.6\%$  and  $61.0 \pm 0.5\%$ , and Density was  $939.2 \pm 0.1 \text{ kg/m}^3$  before and after accelerated oxidative aging, respectively.
6. Hitt, K., et al., "Anthropometric Measurement of the Human Knee: correlation of to the Sizing of Current Knee Arthroplasty Systems," JBJS, Vol. 85-A, Supplement 4, 2003.
7. Stryker test data RD-03-041 and RD-04-027.
8. Stryker initiated Dynamic Computer Simulations of Passive ROM and Oxford Rig Test, Stephen Piazza, 2003
9. Churchill, D.L., Incavo, S.J., Johnson, C.C., Beynnon, B.D., The Transepicondylar Axis Approximates the Optimal Flexion Axis of the Knee, Clinical Orthopaedics. Nov. 1998 (356): 111-8.
10. Robertson, O., Knutson, K., Lewold, S., Lidgren, L., The Swedish Knee Arthroplasty Register, Outcome with Special Emphasis on 1988-1997. Department of Orthopedics, University Hospital.
11. Contact fatigue testing was conducted on accelerated aged sequentially crosslinked and annealed (X3<sup>®</sup>) UHMWPE and control materials. Testing involved translating a 22mm CoCr femoral head across 5 mm thick samples at 0.5 Hz under a 200 N load for a contact stress of 62 MPa. Control materials were nitrogen packed and gamma-radiation sterilized and air packed and gamma-radiation sterilized UHMWPE's. X3<sup>®</sup> samples were unsterilized. All contact fatigue samples were ASTM F2003 accelerated aged (5 ATM of oxygen at 70°C for 14 days). Testing induced cracking in control materials in as little as 0.5 million cycles while proposed material samples showed no signs of pitting, cracking (surface or subsurface) after 5 million cycles. Control material cracks progressed to gross material loss (delamination). The results of the in-vitro delamination tests have not been shown to correlate with clinical delamination mechanisms.
12. Stryker Test Report. Multi-Axis Dynamic Fatigue Test MTP101.0-02.
13. Greene, K.A., Range of Motion: Early Results from the Triathlon<sup>®</sup> Knee System, Stryker Literature Ref # LSA56., 2005.

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A surgeon must always rely on his or her own professional clinical judgment when deciding to use which products and/or techniques on individual patients. Stryker is not dispensing medical advice and recommends that surgeons be trained in knee implant surgeries before performing any knee surgeries.

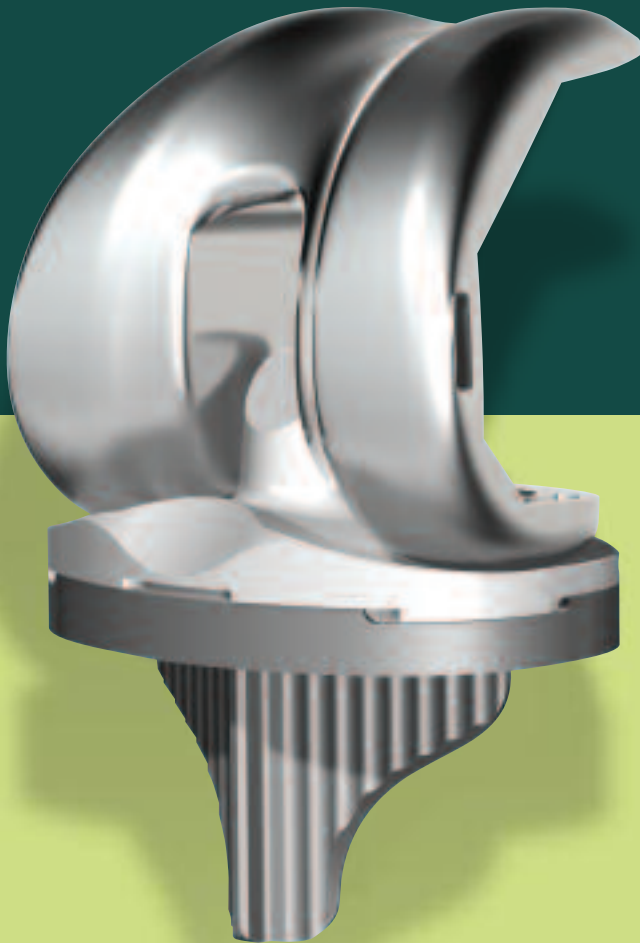
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# Triathlon Knee System

## The Science of:

- Increased motion<sup>8</sup>
- Better fit<sup>9</sup>
- Improved wear performance<sup>10</sup>



## Learn how Triathlon was designed with women in mind.

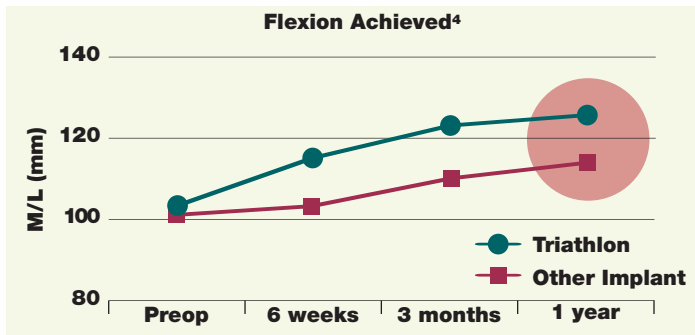
- Over 60% of total knee replacements are performed on women.<sup>1</sup>
- Triathlon was the first total knee system designed with women in mind.
- The design of Triathlon offers a wide range of sizing options that closely match both the female and male anatomy.<sup>9</sup>
- The smaller sizes are narrower, and a narrower implant accommodates the female bone structure, which improves fit and function for women.<sup>9</sup>

# Triathlon Knee System

- Increased motion<sup>8</sup>
- Better fit<sup>9</sup>
- Improved wear performance<sup>10</sup>

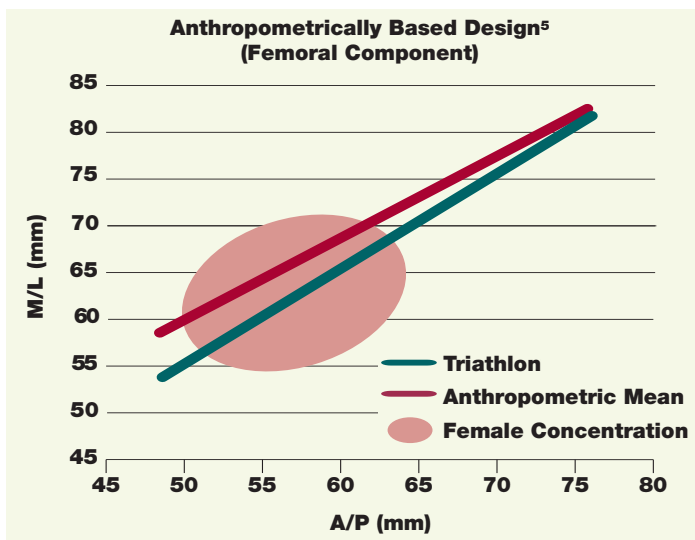
## Increased Motion

- Design features such as a patent pending anatomic radius, deep flexion radius and flared posterior condyles, as well as Rotary Arc and anatomic patellofemoral track allow the Triathlon Knee System to maintain substantial contact area throughout the entire range of motion.<sup>2</sup>
- The deep flexion features of the components are designed to help increase rotation in deep flexion without sacrificing stability.\*
- The femoral geometry in conjunction with the Rotary Arc accommodate increasing amounts of internal/external rotation as necessitated by greater degrees of flexion.<sup>3</sup>
- Patients achieve 12-15% increase in motion after one year.<sup>4</sup>



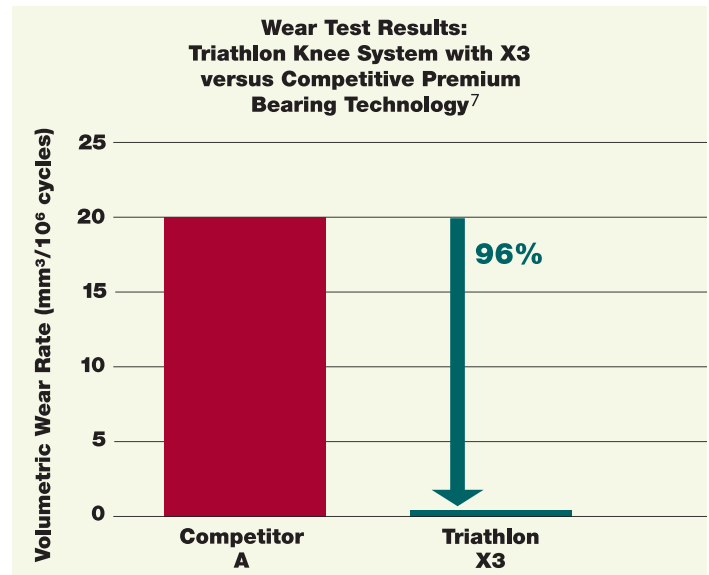
## Better Fit

- Broad range of size offerings are based on an anthropometric measurement study<sup>5</sup> for improved interplay between implant geometry and anatomic structure for women and men.
- A 7-degree anterior flange is designed to enable downsizing with lower incidence of notching.
- Designed with women in mind, the Triathlon design incorporates a variable aspect ratio to better fit the female anatomy while still accommodating the male population.



## Improved Wear Performance

- The durability of knee implants is dependent on the bearing material in conjunction with the appropriate balance of conformity and constraint.
- An appropriate degree of conformity throughout the entire range of motion is designed to reduce contact stresses and wear, offering the potential for enhanced long-term component durability.<sup>6</sup>
- The combination of Stryker's X3 Advanced Bearing Technology and the Triathlon Knee System, has demonstrated a 96% wear reduction in laboratory testing on wear simulators over the leading competitive premium bearing technology.<sup>7</sup>



1. American Academy of Orthopedic Surgeons.
2. Stryker initiated Dynamic Computer Simulations of Passive ROM and Oxford Rig Test, Stephen Piazza, 2003.
3. Stryker Orthopaedics Test Report RD-03-041.
4. Hitt, K., presented at Snowmass meeting, February 2006.
5. Hitt, K., et al., "Anthropometric Measurement of the Human Knee: Correlation to the Sizing of Current Knee Arthroplasty Systems," JBJS, Vol. 85-A, Supplement 4, 2003.
6. D'Lima, D.D., Chen, P.C., Colwell, C.W. Jr., "Polyethylene Contact Stresses, Articular Congruity, and Knee Alignment," Clin Orthop. 2001 Nov; (392):232-8.
7. Stryker Orthopaedics Test Report: RD-06-013.
8. Greene, K.A. Range of Motion: Early Results from the Triathlon® Knee System, Stryker Literature Ref # LSA56., 2005.
9. Hitt, K., et al. Anthropometric Measurement of the Human Knee: correlation to the Sizing of Current Knee Arthroplasty Systems, JBJS, Vol. 85-A, Supplement 4, 2003.
10. Stryker Orthopaedics Test Report: RD-06-013.

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# Triathlon® Knee System with Peri-Apatite™

**Peri-Apatite™ is Stryker's  
Patented Technology for applying a  
biologic coating to three-dimensional  
in-growth surfaces.**



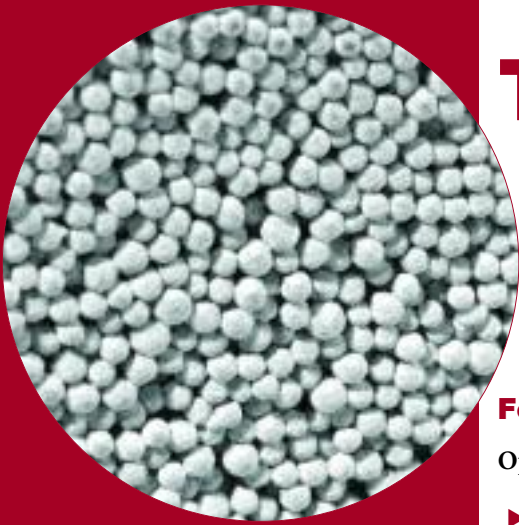
## **Optimized coverage for porous surfaces**

- ▶ Three-dimensional coverage<sup>1</sup>
- ▶ Average hydroxyapatite (HA) coating thickness of 20  $\mu\text{m}$  to allow for in-growth<sup>1</sup>

## **Bone-like hydroxyapatite**

- ▶ 100% crystalline HA<sup>2</sup>
- ▶ High surface area like bone crystals<sup>1</sup>





**Peri-Apatite™ was developed to coat hydroxyapatite onto porous coated fixation surfaces**

# Triathlon® Knee System with Peri-Apatite™

## Features

### Optimized Coverage for Porous Surfaces

- ▶ The surface area of Peri-Apatite™ HA is approximately 1000 times greater than that of the HA plasma sprayed coatings.<sup>1</sup>
- ▶ The crystals deposited from the Peri-Apatite™ form an HA coating with an overall average thickness of 20 µm, which allows for bone in-growth.<sup>1</sup>

## Benefits

- ▶ As opposed to plasma-sprayed HA coatings, Peri-Apatite™ HA coating wraps itself around the circumference of the porous surface, increasing the HA surface available for fixation<sup>1</sup> (see figure below).
- ▶ The Peri-Apatite™ HA coating does not block the openings of the porous metal implant.

## Triathlon® Knee System

### Increased Motion

- ▶ The Triathlon® Knee System allows for natural knee motion and up to 150 degrees of flexion.

### Better Fit

- ▶ The design of Triathlon® offers a wide range of sizing options that closely match both female and male anatomy.<sup>5</sup>

### Improved Wear Performance

- ▶ New test results show Stryker's Triathlon® Knee System with X3® advanced bearing technology demonstrates up to 96% less wear than competitive premium bearing technology.<sup>4</sup>

The image below depicts the distinct advantage of the Peri-Apatite™ technique. PA uniformly coats three-dimensional surfaces providing a larger surface area for fixation thus avoiding coating only substrate surfaces in the direct line with the plasma spraying HA technique.<sup>1</sup>

### Peri-Apatite™ HA Coating Coverage



**This image compares the solution-deposited or PA coating versus the plasma-sprayed HA coating. The Peri-Apatite™ coating is depicted on the left side of the image. HA = red.**

### Bone-like Hydroxyapatite

- ▶ Deposited PA coating is 100% crystalline HA, whereas the HA coating deposited from plasma spraying is less pure and less crystalline.<sup>2</sup>
- ▶ A consistent HA coating purity and crystallinity allows for reliable and reproducible *in-vivo* performance of Peri-Apatite™ HA coating for implant fixation.<sup>2</sup>

1. Serekian, Paul (2004), Hydroxyapatite: from Plasma Spray to Electrochemical Deposition. From: Fifteen Years of Clinical Experience with Hydroxyapatite Coatings in Joint Arthroplasty: Edited by Jean-Alain Epinette and Michael T. Manley. Springer, France, pp 29-33.
2. Zitelli, Joseph P. and Higham, Paul (2000), A Novel Method For Solution Deposition of Hydroxyapatite Onto Three Dimensionally Porous Metallic Surfaces: Peri-Apatite HA. Materials Research Society Symposium Proc., Vol. 599.
3. Stryker Orthopaedics Test Report 04-039.
4. Stryker Orthopaedics Test Report RD-06-013.
5. Hitt, Kirby, et al: Anthropometric Measurement of the Human Knee: Correlation to the Sizing of Current Knee Arthroplasty Systems, JBJS, Vol. 85-A, Supplement 4, 2003.

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325 Corporate Drive  
Mahwah, New Jersey 07430  
t: 201.831.5000

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