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FREEDOM® KNEE

Femoral Design: High Flex

FREEDOM KNEE SYSTEM OVERVIEW

The Freedom Total Knee® System was developed using advanced design engineering technologies and extensive clinical experience to address the anatomical, physiological and lifestyle needs of today's patients. The system's significant design advances allow patients to achieve optimal high-flexion motion regardless of whether the all-poly or metal-backed tibial component is chosen. This approach provides surgeons with unique component options that deliver successful, predictable and reproducible results.

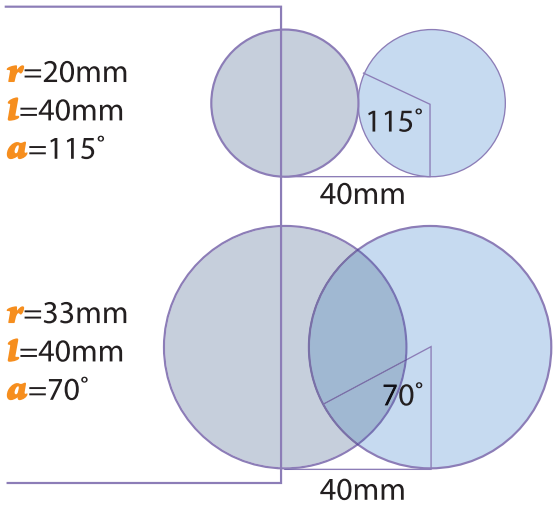
MULTI-RADIUS DESIGN: FORM FOLLOWS FUNCTION

The articular surface of the Freedom femoral components were designed to mimic anatomical knee function: as flexion increases, the radius of curvature in the sagittal plane must change to accommodate more or less rollback over the available surface.

For example, to decrease femoral rollback over a given radius length, the arc of that radius must be increased. Furthermore, each radius must be tangent to the next to ensure smooth transitions.

Therefore, in walking gait, the radii of curvature must be large to inhibit significant rollback, while in deep flexion, the radii must be increasingly smaller to encourage considerable rollback over the relatively small surface area of the posterior condyles.

Figure 1: Geometry of Articulation

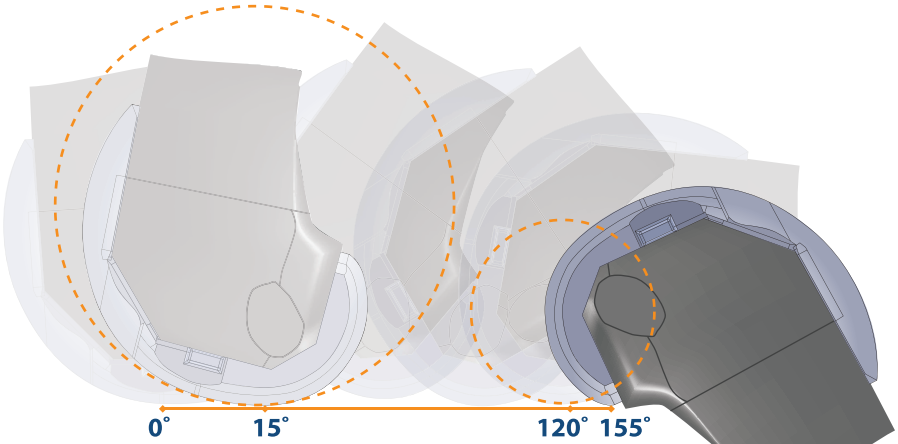


A circle with a given radius ***r*** which travels over an arc length ***l*** rotates ***a*** degrees.

An increase in ***r*** results in a proportionate decrease in ***a***.

So…a larger radius means less rollback over the same distance.

Figure 2: Example of Femoral Rollback, Size "E"



large radius = **15˚** rollback over **14**mm

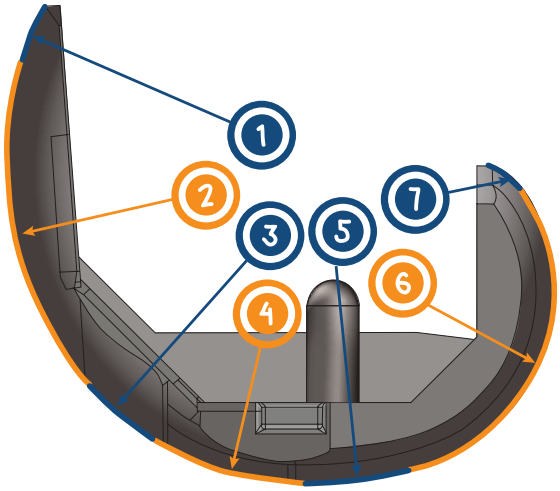
medium radius = **105˚** rollback over **42**mm

small radius = **35˚** rollback over **6**mm

The desire to manage implant articulation constrains not only femoral-tibial contact but also femoral-patellar contact, especially when the anterior flange of the femoral component is thin.

Figure 3: 7 Radii of Curvature

Radii ①, ② and ③ manage patellofemoral contact…they must be tightly controlled for smooth tracking over a thin anterior flange.



Radii ④, ⑤, ⑥ and ⑦ control femoral rollback and flexion over a wide array of biomechanical requirements, from walking to climbing stairs.

Each of the 7 radii on the femoral articular surface plays a critical role in managing articulation within the joint space.

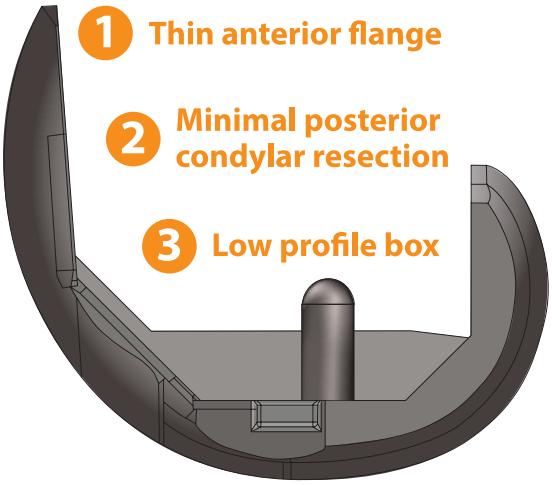
HIGH FLEXION & BONE CONSERVATION

The Freedom femoral components have been designed to permit flexion of 155°. While reaching higher degrees of flexion is dependent upon patient anatomy, an increasing patient population is requiring this capability, and this is especially true in Asia and other regions where squatting and kneeling are activities of daily living.

However, modern knee implant design must not only accommodate high flexion but must also address the need for bone conservation. Minimizing bone resection is critical to all patients with smaller or narrower bones (particularly true in Asian anatomy) and is also important to younger patients who may have to undergo a revision knee Arthroplasty, should they outlive their primary implants.

The Freedom knee was the first system developed from conception with the requirements of both high flexion and bone conservation as critical elements of its design. Because the components were designed with both requirements, we have achieved the same level of flexion as other contemporary designs, while removing significantly less bone.

Figure 4: Bone Conserving Features of the Freedom Femoral Component



The anterior flange design reflects both the components bone-conserving design and the desire to accommodate a variety of surgical techniques. While the flange is thin, the trochlear groove was deepened to allow for smooth articulation and excellent tracking, whether or not the surgeon has elected to resect the patella.

When developing a high-flex femoral component, one of the most critical and confounding features is the posterior condylar articulation. Through multi-radius design, we have minimized posterior condylar resection, while allowing for 155° of flexion. For example, two popular high-flex systems require 33% more posterior condylar resection than the Freedom Knee, for similarly sized components.[1]

Figure 5: Posterior Condylar Resection

	A	B	C	D	E	F	G
Freedom	7.2	7.7	8.2	8.5	8.8	9.4	9.8
NexGen					12.0		
Sigma RPF					12.0		

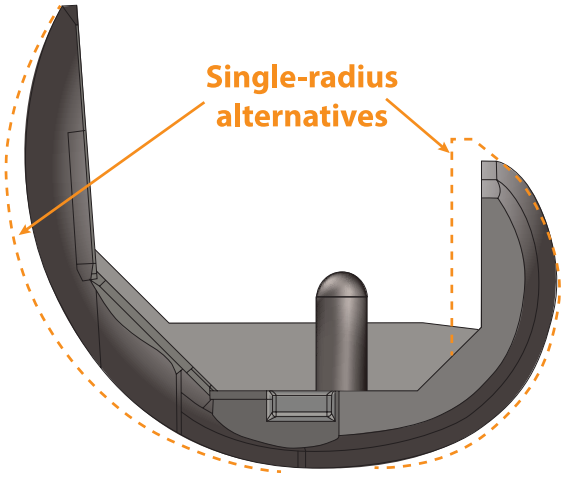
Similarly, in a study conducted by Haas et al., the average box cut bone resection volume for small femoral components from five systems was 9.52 cm3, while a comparably sized Freedom component requires 6.44 cm3.[2]

Figure 6: Freedom Box Cut Bone Resection (cm3), by Size

A	B	C	D	E	F	G
4.37	5.42	6.44	7.14	7.91	9.69	11.26

Multi-radius design with an eye toward bone conservation resulted in a system with both superior flexion characteristics and some of the thinnest, most bone-conserving components available globally. An alternative, single-radius design would have resulted in a considerably lower performing system, as pictured below.

Figure 7: Affect of Single-radius Design



A single radius across the patellofemoral contact area would increase the thickness of the anterior flange by 1-2mm.

Achieving high flexion by extending a single radius around the tibiofemoral contact area would require taking 1-2mm of additional posterior condylar bone.

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REFERENCES

1. Maxx Orthopedics internal analysis.

2. S.B. Haas et al. *The Knee.* 2000; 7:25-29.

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