

In-Vivo Kinematic Analysis of Evolution[®] Medial-Pivot Total Knee Arthroplasty during Weight-Bearing Activity

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Background

Total knee arthroplasty (TKA) is the most effective surgical treatment for patients with severe osteoarthritis of the knee ^{1,2}. The physiological motion of the normal knee joint shows a posterior sliding of the lateral femoral condyle on the tibial plateau while a pivoting movement on the medial compartment ^{3,4}. One of main goals of TKA implant design is to produce kinematics at least similar to such normal knee. The Medial-Pivot (MP) TKA has been developed to replicate the medial pivot motion seen in normal knee by modifying joint geometry ⁵. However, it is still controversial as to whether or not this MP implant can actually reliably reproduce such desired kinematics in vivo.

The purpose of the present study is to examine the three-dimensional in-vivo kinematics in the MP TKA during weight-bearing activity.

Patient's demographic data

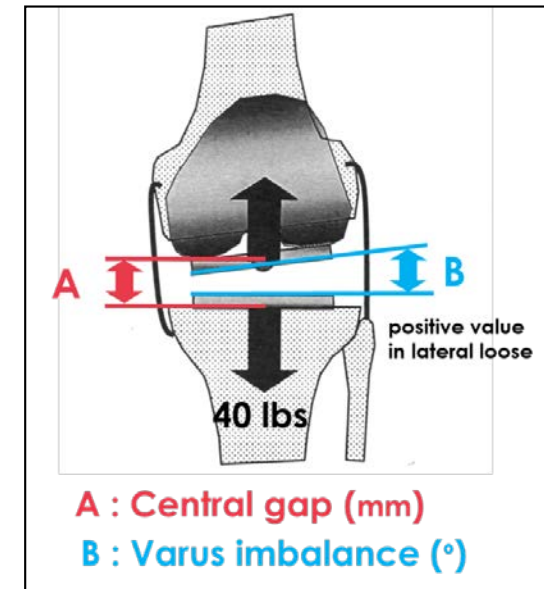
- Eighteen patients who required a unilateral TKA for severe medial osteoarthritis were enrolled.

(mean \pm SD)

Knees	18
Age at surgery (y.o.)	76 \pm 6
Gender (Male/Female : female %)	8/10 : 56
Preop. Knee Extention angle ($^{\circ}$)	4 \pm 4
Preop. Knee Flexion angle ($^{\circ}$)	120 \pm 13

Surgical procedures

- Prosthesis : Evolution® (MicroPort) + Cruciate-substituting bearing
- PCL resection
- Mechanical alignment
 - ✓ Rotation of femoral comp. : parallel to SEA
 - ✓ Rotation of tibial comp. : parallel to Akagi's line
 - ✓ Tibial posterior inclination : 6° (adjustment by insert)
 - ✓ No patellar resurfacing
- Soft tissue balance : **Medial tight**
 - Implant gap measured using an offset tensor (40lbs)
 - **Δ Central gap** (the value of 90° - the value of 0°) : **< 5 mm**
 - **Varus imbalance** (positive value in lateral loose) : **< 5° at all ROM**



Evaluation

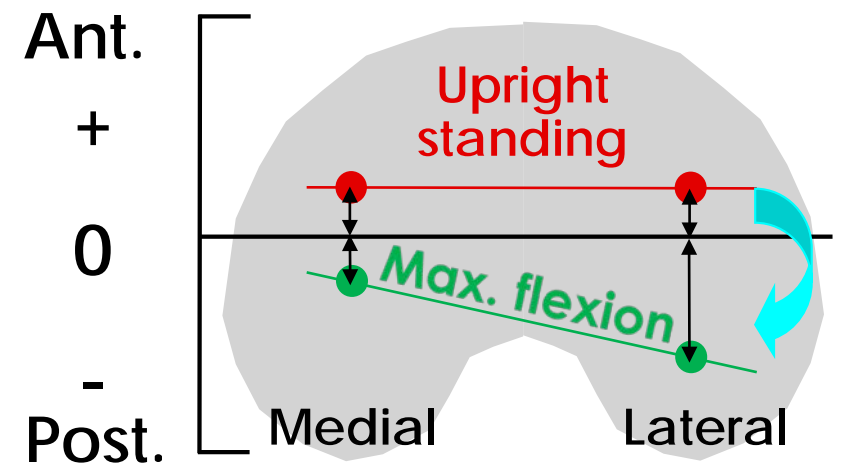
- Clinical evaluation : Pre-operation and 1-year post-operatively
 - 1) The new Knee Society Scoring System (KSS)
 - 2) Knee Injury and Osteoarthritis Outcome Score (KOOS)
- 3D kinematic analysis : 1-year post-operatively
 - 2D/3D registration technique : lunge & step-up
 - measuring at the interval of 5°

1) Femoral AP translation

- zero: center line on tibial AP width
- negative value in posterior

2) Tibial rotation relative to the femur

- negative value in external rotation

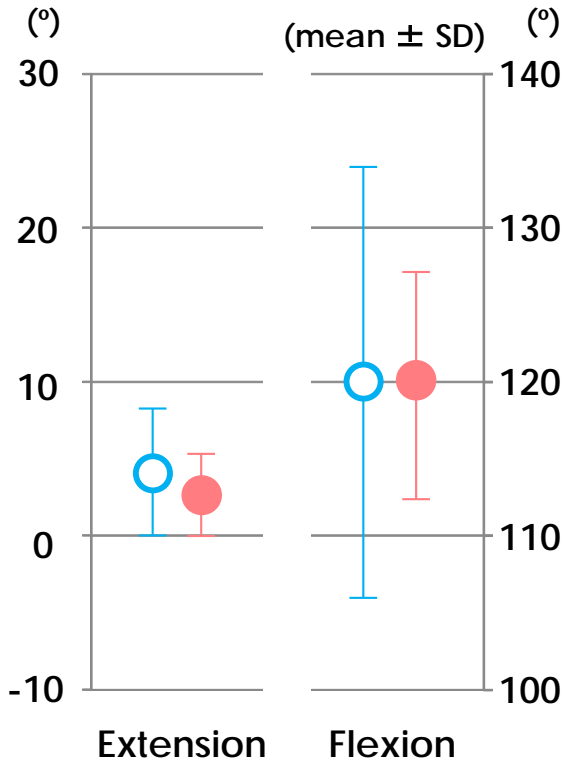


Clinical evaluation

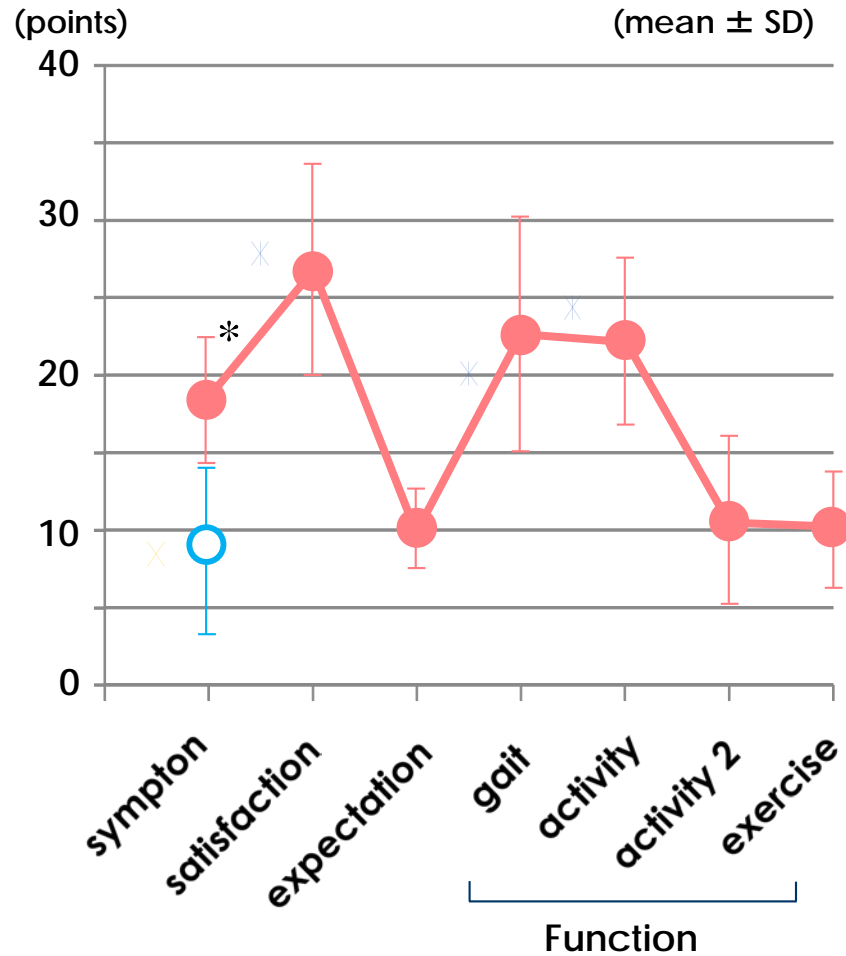
○ Preop. ● Postop.

* $p < 0.05$; Student t-test

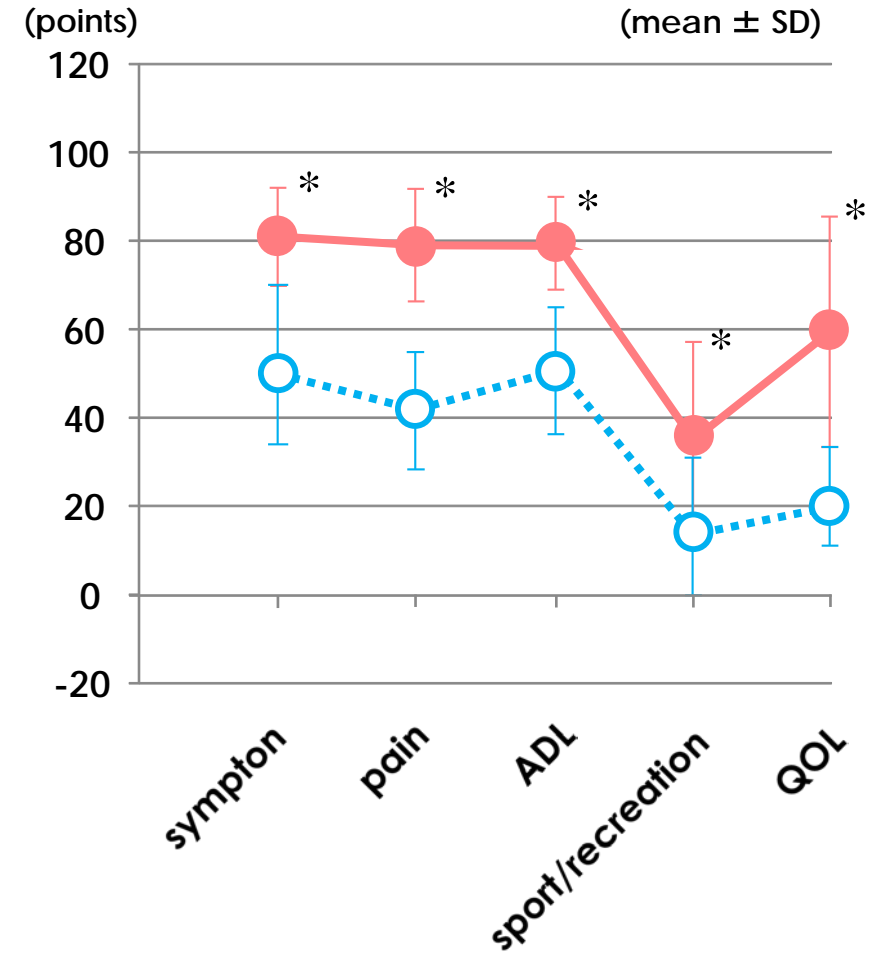
ROM



KSS



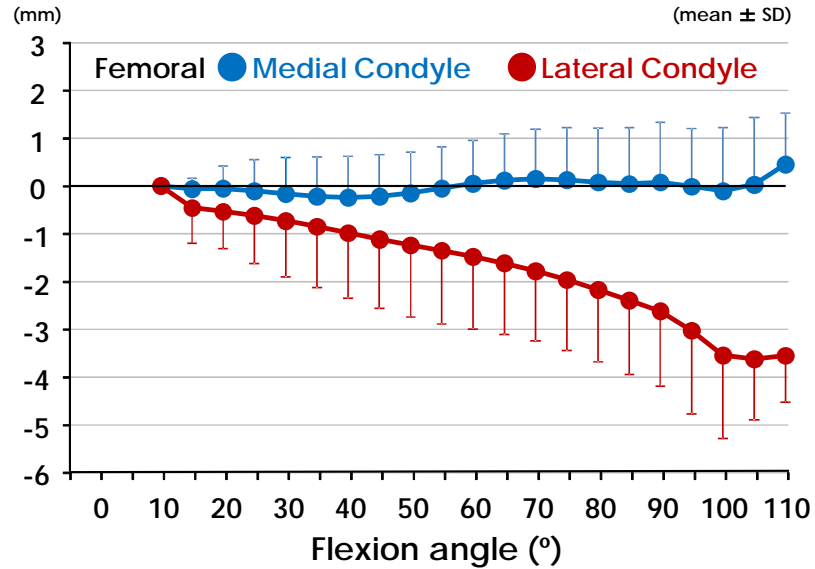
KOOS



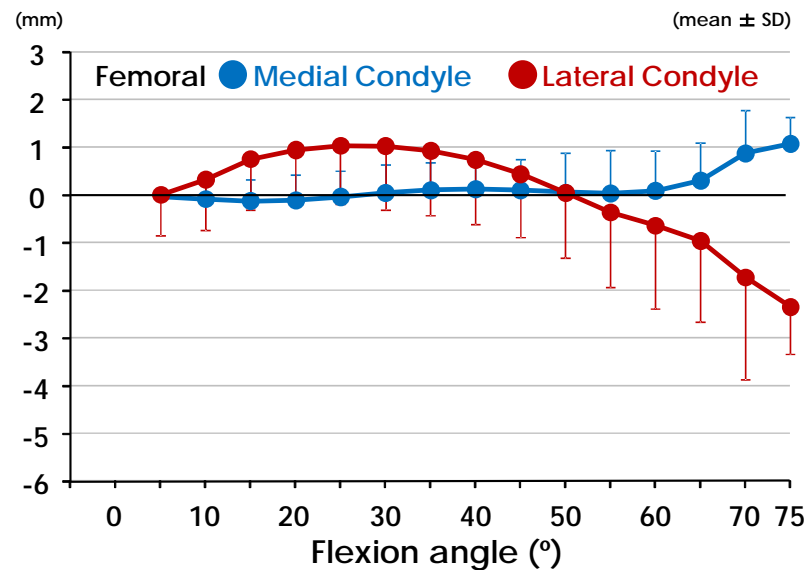
3D kinematic analysis

lunge

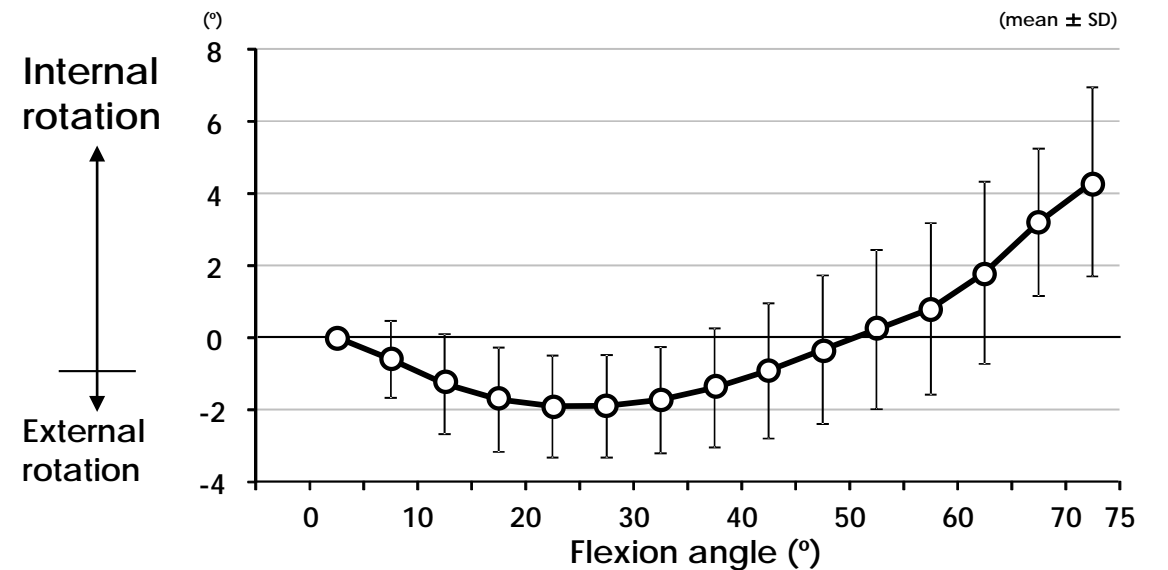
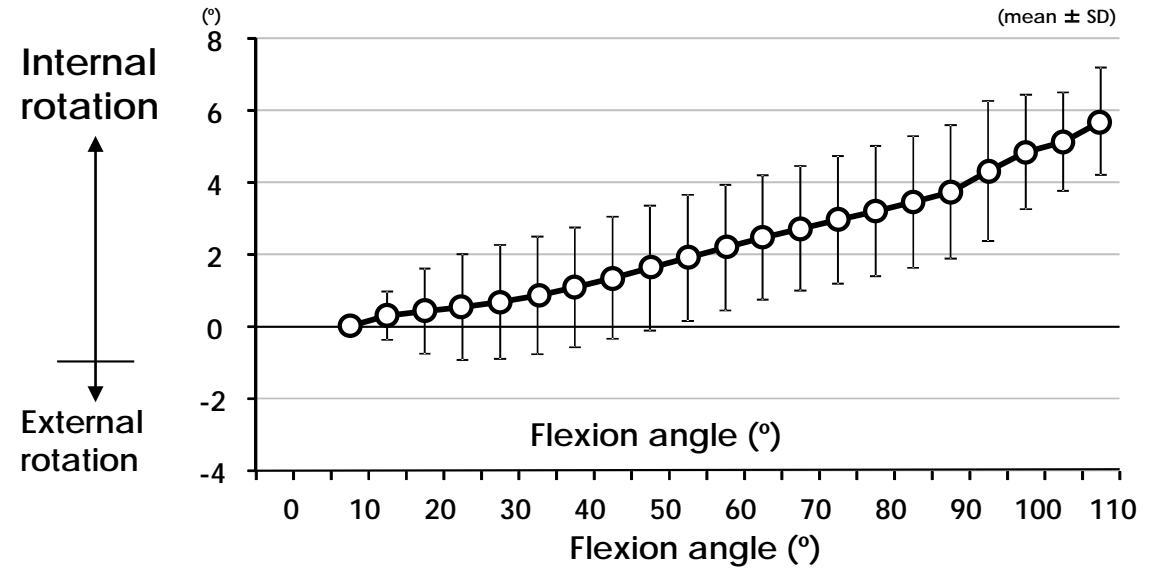
AP translation



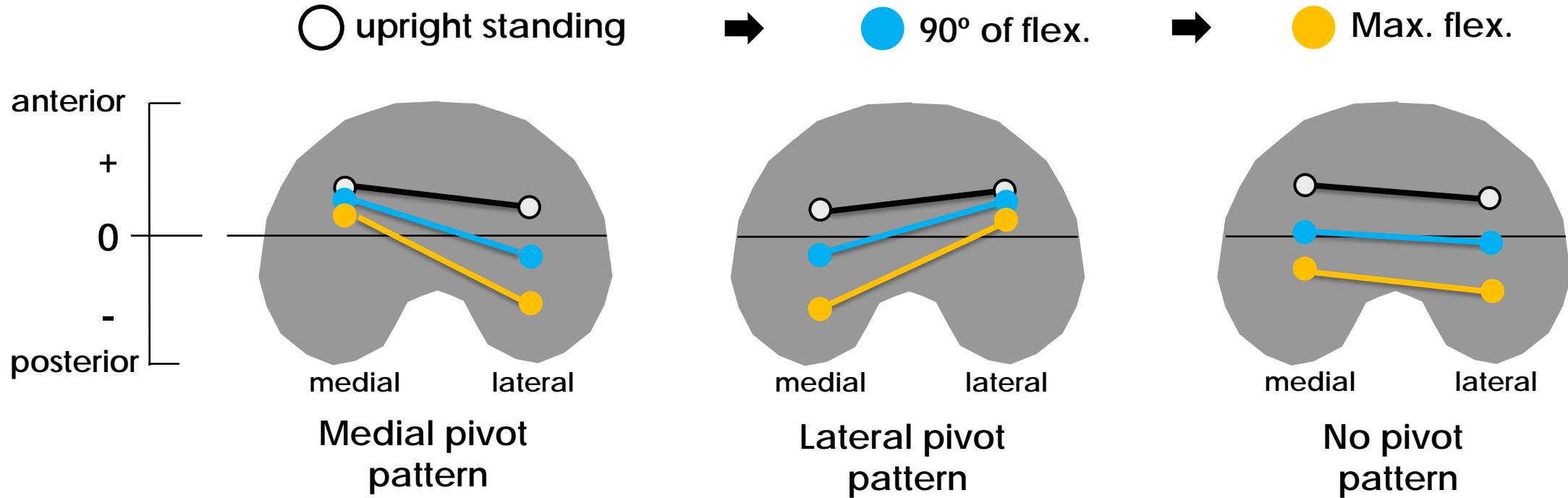
step-up



Tibial rotation



Motion pattern of the femoral comp.

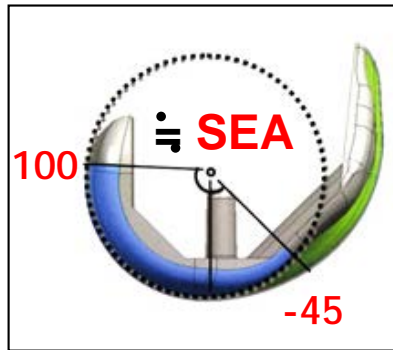


lunge	15/18 (83%)	0/18 (0%)	3/18 (17%)
step-up	13/18 (72%)	0/18 (0%)	5/18 (28%)

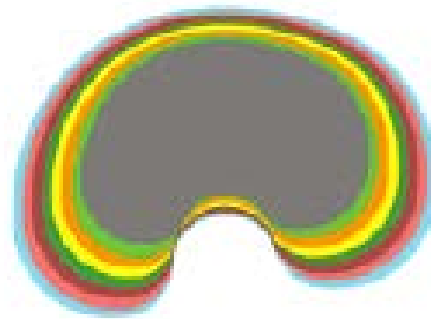
A second generation medial-pivot system : EVOLUTION[®] 6

(MicroPort Orthopedics Inc., Arlington, TN, USA)

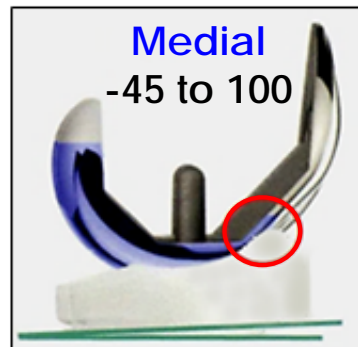
- Single-radius design of the femoral comp.



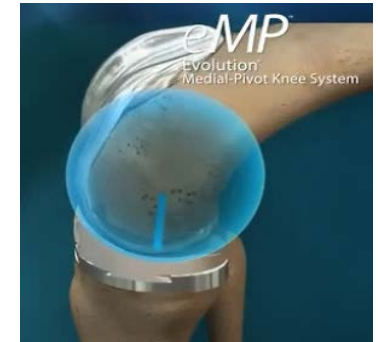
- An asymmetrical tibial insert



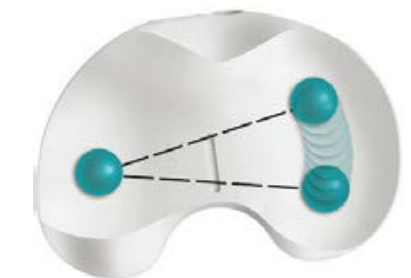
- Cruciate-Substituting (CS) bearing : medial anterior and posterior lip providing to substitute for both the PCL and ACL



Femoral comp. parallel to SEA



- Medial compartment : Controlling the femoral AP translation
- Lateral compartment : Allowing unrestricted femoral movement

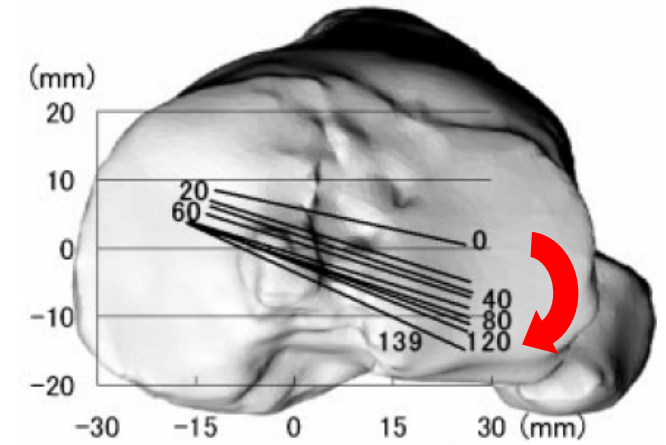
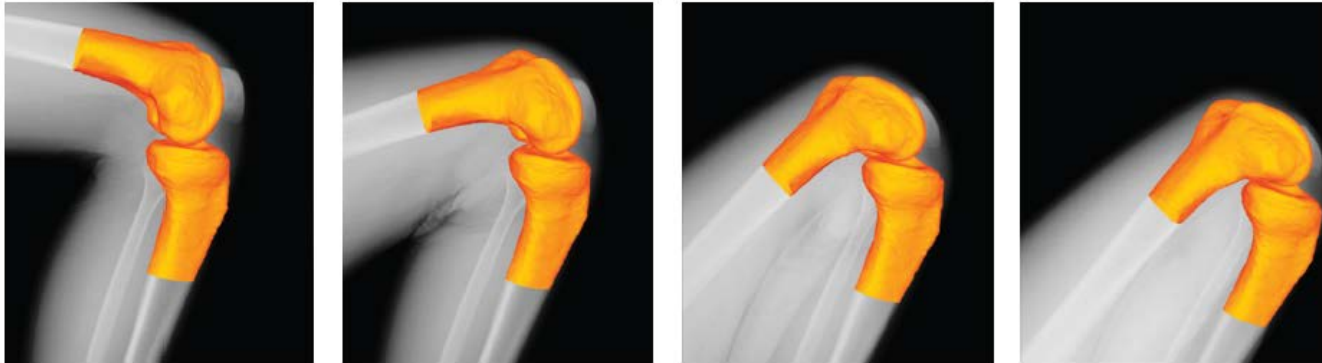


medial lateral

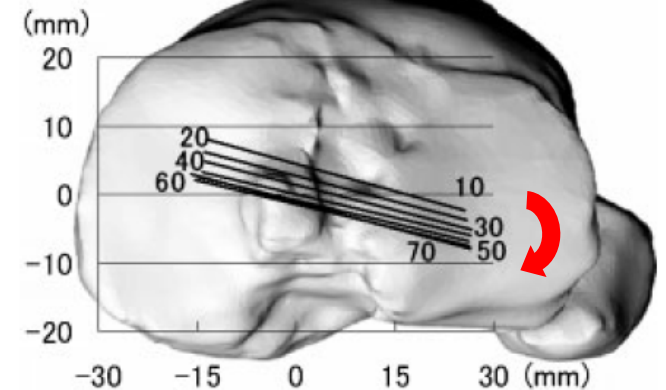
Reproducing the medial pivot motion

Dynamic 3D normal Knee Kinematics during lunge & step-up

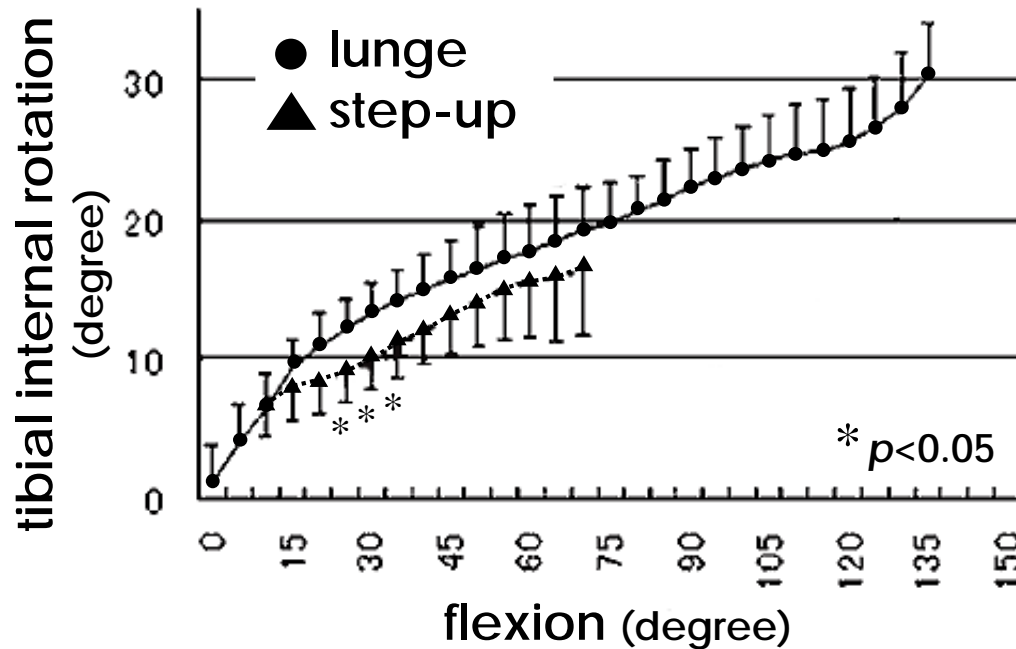
Moro-oka T, et al. ⁴ *J Orthop Res* 2008



lunge contact points



step-up contact points



Conclusion

- The knees implanted with EVOLUTION® MP knee arthroplasty showed at higher reproducibility, during flexion in weight-bearing, a medial pivot motion with a stable AP contact position of MFC and rollback of LFC. Such in-vivo kinematics is consistent with the implant design intent, in spite of the magnitude in tibial internal rotation less than the normal knee.
- There are some limitations in the present study. First, this study is a study with small sample size in postoperative early phase. Further studies with larger samples are needed.

References

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Thank you for your kind attention