INTRODUCTION: Squatting and kneeling are important functions of the knee joint, and required for many daily activities regardless of the age and activity level. Although previous in-vivo kinematic analyses of the total knee arthroplasty (TKA) implanted knee have shown contact condition in various activities, contact status in deep knee flexion has not been well clarified. Especially, for the posterior stabilized TKA, posteriorly directed load to the proximal tibia in kneeling position can cause excessive stress at the post-cam interface. Recently, concern has been raised in the point that a high contact force applied to the post-cam mechanism may lead to early wear or breakage of the prosthetic component. We have developed a new post-cam design to allow the deep knee flexion while avoiding the generation of excessive stress at the interface, and early clinical results have been obtained. In this study, contact condition of this post-cam system during kneeling was assessed in vivo to confirm the clinical validity of this TKA design modification.

METHODS: The contact position of the post-cam was analyzed for 10 subjects implanted with posterior stabilized TKA prosthesis of EMK system (Japan Medical Materials, Osaka, Japan). The posterior stabilized component of this system possesses a unique design of helical shaped post. This new shape of the post-cam system allows the physiological internal rotation of the tibia during knee flexion (Figure 1). For the image analysis, the lateral radiographs were taken in the following three positions: with 1) straight-legged standing, 2) squatting position, where the foot was placed on a 30cm step and the patient flexed the knee to maximum comfortable flexion, and 3) kneeling position on a padded bench with maximum knee flexion. All subjects were analyzed using a two-dimensional to three-dimensional (2D/3D) registration technique [1]. Contact of the components at the post-cam mechanism was determined by evaluating the minimum distance between the post and the cam in the posterior stabilized TKA has been pointed out as a potential cause of prosthetic failure [2]. With the intent of reducing the stress at the interface, the EMK prosthesis was designed to allow physiological internal rotation of the tibia in flexion while achieving a large contact area. The results of this study have shown that this design modification may reduce the contact stress and rotational mismatch at post-cam interface. There are still controversies as to the rotational movement during flexion after TKA. Previous in-vivo fluoroscopic analyses have shown the presence of abnormal axial rotation pattern during weight bearing flexion. It is generally believed that a normal axial rotation pattern is desirable for allowing physiological patellar tracking, reducing patellofemoral shear forces, and maximizing knee flexion. In this study, most of the subjects experienced a normal pattern of axial rotation during kneeling and squatting positions, showing additional potential advantage afforded by the design modification.

RESULTS: At straight-legged standing, the average flexion angle was -4.4º ± 7.6º and the axial tibial rotation angle was -0.7º ± 1.5º, while the corresponding values were 99.3º ± 13.2º and 6.8º ± 4.2º at squatting. In the kneeling position, the average flexion angle was 123.3º ± 7.9º and the axial tibial rotation angle was 8.0º ± 4.0º. Figure 2 visualized virtual contact condition of the tibial post in the squatting and kneeling conditions in the representative three cases. As shown in the figures, in majority of the cases, contact over the large area between the femoral cam and tibial post surfaces were achieved (Figure 2-a, b, c, d). However there was also a case presenting a limited contact area with less associated tibial internal rotation (Figure 2-e, f).

DISCUSSION: Recently, the possibility of excessive contact stress between the post and the cam in the posterior stabilized TKA has been pointed out as a potential cause of prosthetic failure [2]. With the intent of reducing the stress at the interface, the EMK prosthesis was designed to allow physiological internal rotation of the tibia in flexion while achieving a large contact area. The results of this study have shown that this design modification may reduce the contact stress and rotational mismatch at post-cam interface. There are still controversies as to the rotational movement during flexion after TKA. Previous in-vivo fluoroscopic analyses have shown the presence of abnormal axial rotation pattern during weight bearing flexion. It is generally believed that a normal axial rotation pattern is desirable for allowing physiological patellar tracking, reducing patellofemoral shear forces, and maximizing knee flexion. In this study, most of the subjects experienced a normal pattern of axial rotation during kneeling and squatting positions, showing additional potential advantage afforded by the design modification.

REFERENCES:

**Kobe University Graduate School of Medicine, Kobe, Japan.
***University of Hyogo, Himeji, Japan.
****Hyogo College of Medicine, Nishinomiya, Japan.

ACKNOWLEDGEMENT:
The authors wish to thank Japan Medical Materials (Osaka, Japan) for providing the computer models of knee prosthesis.

Figure 1. A lateral radiograph at kneeling, the view with the prosthetic silhouette overlaid, and the top and the rear view of the prosthetic contact condition are illustrated.

Figure 2. In vivo post-cam contact position:
(a) Patient 1-left knee, squatting (flexion 106.6º, axial rotation 8.1º)
(b) Patient 1-left knee, kneeling (flexion 133.4º, axial rotation 10.8º)
(c) Patient 2-right knee, squatting (flexion 108.8º, axial rotation 12.5º)
(d) Patient 2-right knee, kneeling (flexion 129.7º, axial rotation 12.9º)
(e) Patient 3-right knee, squatting (flexion 109.0º, axial rotation 1.4º)
(f) Patient 3-right knee, kneeling (flexion 128.7º, axial rotation 3.2º)