CONTACT STRESS ANALYSIS OF THE “CONFORMING” POST-CAM MECHANISM IN POSTERIOR STABILIZED TOTAL KNEE ARTHROPLASTY

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INTRODUCTION:
Posterior-stabilized total knee arthroplasty (TKA) has been widely used and long-term follow-up studies have reported satisfactory results. However, complications involving the post-cam mechanism, such as knee dislocation, post fractures, or severe wear of the post have been reported. Surgeons have sought greater range of motion after TKA; however, biomechanical studies have shown that very high anterior-posterior shear force is generated at the tibio-femoral joint during deep knee flexion. Therefore, there is concern that a higher contact force would be applied to the post-cam mechanism with a greater flexion angle after posterior-stabilized TKA. Recently, the post-cam designs have been modified to have larger contact area or to avoid impingement in tibial rotation. This study was designed to evaluate the effects of the post-cam design on contact area, contact stress, and contact location at the post and cam mechanism of the posterior-stabilized prosthesis.

MATERIALS AND METHODS:
The five posterior-stabilized type total knee prostheses were used (Table 1). Each femoral component was attached to a fixture that provided a flexion-extension range from 90, 120, and 150 degrees. A compressive posterior load of 500 N, parallel to the tibial joint surface, was applied to the tibial component against the femoral component. A digital electronic stress sensor (K-Scan sensor) was placed at the post-cam interface to measure peak and mean contact stresses and contact area. Measurements were done at 90°, 120°, and 150° of knee flexion. Each measurement was performed five times for each component to permit calculation of variance across the testing conditions. The distance from the deepest part of the tibial surface to the center of the contact area was also measured. Contact area, peak contact stress, and contact location were compared among the components at each flexion angle.

RESULTS:
Contact area: The TRAC and the Alpina showed the largest contact area at 90°of flexion, but decreased as the knee flexed. The Scorpio NRG and the PFC Sigma RPF increased contact area as the knee flexed, and the PFC had the largest contact area at 150°. The NexGen showed minimal changes between 40 to 50 mm² at three different angles (Figure 1).
Peak contact stress: Contact stress did not change significantly in each component with internally rotated tibia (Figure 2).
Contact location: Considerable difference was found in contact location of each component. The NexGen showed the lowest contact location throughout knee flexion, and the Scorpio NRG had the highest contact point among the components (Figure 3).

DISCUSSION
Significant difference was found in contact area of the post-cam mechanism among the five posterior stabilized knee components. The PFC Sigma RPF had large contact area at 150° of flexion, which would avoid post breakage in deep knee bending, and the TRAC and the Alpina showed large contact area at 90° of flexion, which would achieve better wear performance in daily activity such as standing up from the chair.
All of the five components did not increase contact stress with internally rotated tibia due to round on round contact configuration in axial plane or mobile bearing mechanism. These findings suggest that these components have less chance to have severe wear of the post by edge loading.
The contact location with the NexGen LPS Flex stayed lower than the other components. This feature is beneficial for avoiding excessive stress at the bone-implant interface and to prevent post fracture.
The results of this study showed that recent modification of the post-cam designs increased contact area and would cause less impingement in tibial rotation. Further modification would be also necessary to adapt for different kind of knee motion such as lifting-off.

| Table 1 Design characteristics of the post-cam of the five posterior stabilized prostheses |
|------------------------------------------|----------|----------|----------|----------|----------|
| NexGen LPS Flex | Scorpio NRG | PFC Sigma RPF | TRAC | Alpina |
| cam shape (sagittal) | oval | oval | oval | round | round |
| mobile /fixed | mobile | fixed | mobile | mobile | fixed |

![Figure 1 contact area](image1.png)

![Figure 2 peak contact stress with internally rotated tibia](image2.png)

![Figure 3 contact locations](image3.png)

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