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Posterior Shift of Contact Point between Femoral Component and Polyethylene in the LCS Rotating Platform Implant under Weight Bearing Condition

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Purpose: To analyze the contact mechanics of the femoral component and polyethylene of the Low Contact Stress rotating platform (LCS-RP) in nonweight bearing and weight bearing conditions using full flexion lateral radiographs.
Materials and Methods: From May 2009 to December 2013, 58 knees in 41 patients diagnosed with osteoarthritis and treated with total knee arthroplasty (TKA) were included in this study. TKA was performed using an LCS-RP knee prosthesis. Full flexion lateral radiographs in both weight bearing and nonweight bearing condition were taken at least one month postoperatively (average, 28.8 months). Translation of femoral component was determined by the contact point between the femoral component and polyethylene. Maximum flexion was measured as the angle between the lines drawn at the midpoint of the femur and tibia.
Results: Posterior shift of the contact point in LCS-RP TKA was observed under weight bearing condition, which resulted in deeper flexion compared to LCS-RP TKA under nonweight bearing condition
Conclusions: In the LCS-RP TKA, the contact point between the femoral component and polyethylene moved posteriorly under weight bearing condition, and the joint was more congruent and maximum flexion increased with weight bearing.

Keywords: **Knee, Osteoarthritis, Arthroplasty, Rotating platform, Contact point**

Introduction

Maximum flexion and femoral rollback or shift in fixed bearing designs are larger than those of the mobile bearing designs, which could imply that mobile bearing total knee arthroplasty (TKA) has a disadvantage with respect to high flexion[1].

However, in a comparison of *in vivo* knee kinematic patterns of mobile bearing TKA with those from studies of fixed bearing TKA and the normal knee, no major differences in the average kinematic patterns of fixed- versus mobile bearing implants were observed[1,2].

The purpose of this study was to analyze the contact mechanics of the femoral component and polyethylene of the mobile bearing TKA in nonweight bearing and weight bearing conditions using full flexion lateral radiographs. Our hypothesis was that more prominent change of the contact mechanics would appear in the setting of weight bearing condition compared to nonweight bearing condition and this change would facilitate deeper flexion after Low Contact Stress rotating platform (LCS-RP) TKA.

Materials and Methods

From May 2009 to December 2013, TKA was performed on 283 knees. In 128 knees, LCS-RP knee prosthesis (DePuy, Warsaw, IN, USA) was used. Inclusion criteria were Kellgren-Lawrence grade 4 osteoarthritis, primary TKA, and no history of surgery on the

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ipsilateral lower extremity. Exclusion criteria were revision TKA, rheumatoid arthritis, infection, and prior trauma to the knee joint. Finally, 58 knees in 41 patients diagnosed with osteoarthritis and treated with TKA were included in this study and Institutional Review Board approval was obtained.

The operation was performed by one senior surgeon (BKL). A standard midline incision was performed and the joint capsule was opened with a medial parapatellar approach. A 9-mm tibial cut was done prior to a 9-mm femoral distal cut, which was followed by ligament balancing. The extension gap (range, 21 to 23 mm) was examined and femoral rotation was determined parallel to the tibial plate with the knee in 90 degree flexion. An anteroposterior (AP) femoral cut was done while maintaining the flexion gap equal to the extension gap. The flexion gap was measured with the knee in 90 degree flexion tensioned with a lamina spreader. If a flexion gap was 1 mm narrower than an extension gap, the AP femoral cutting guide was moved 1 mm anteriorly, whereas if a flexion gap was 1 mm wider than an extension gap, the AP femoral cutting guide was moved 1 mm posteriorly. Postoperatively, all the knees were immobilized in the cylinder splint for 1 day. Patients began ambulation from the 1st postoperative day.

To verify the weight bearing effect of the LCS-RP TKA, maximum flexion in weight bearing and nonweight bearing conditions were evaluated. Full flexion lateral radiographs in both weight bearing and nonweight bearing conditions were taken at least 2 months postoperatively (average, 8 months). The weight bearing full flexion lateral radiographs were obtained by flexing the knee joint in a modified lunge position with the ipsilateral foot placed on a box (Fig. 1).

We modified the method described by de Jong et al.[3] to measure the contact point. For this method, overlapping of the medial and lateral femoral condyles was required. A line was drawn parallel to the inferior surface of the tibial component at the most distal level of the tibial tray (line 1) (Fig. 2).

Fig. 1. The ipsilateral foot was placed on a box and fully flexed with weight bearing.

Maximum flexion was measured as the angle between the lines drawn at the midpoint of the femur and tibia (Fig. 3).

Statistical analysis was performed using SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA). Test of normality was performed using the Kolmogorov-Smirnov test. Paired *t*-test was used for comparison of results before and after weight bearing. A p-value of less than 0.05 was considered statistically significant.

Results

There were 6 males and 35 females, and their average age was 71.7±7.5 years (range, 50 to 81 years; median, 73). The postoperative maximum flexion measured in the out-patient clinic under the nonweight bearing condition and weight bearing condition was $108.4^{\circ}\pm2.26^{\circ}$ and $118.5^{\circ}\pm4^{\circ}$, respectively. Effect of the weight bearing was statistically significant (p=0) (Fig. 4).

Contact points measured on the follow-up full flexion lateral radiographs taken under the nonweight bearing condition and

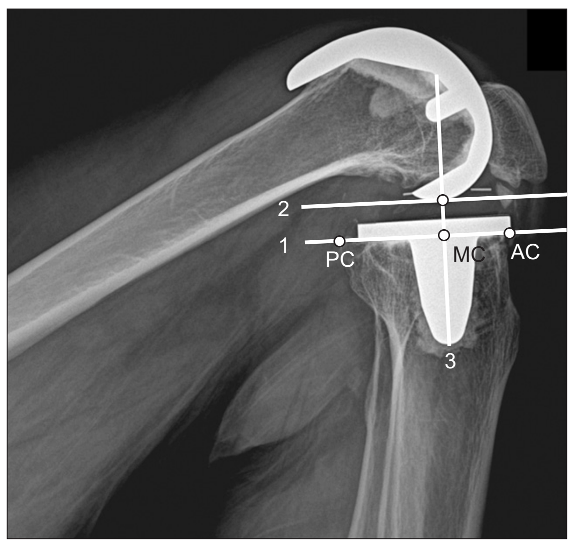

Fig. 2. Modified method of de Jong et al.[3] for evaluation of the contact point. For this method, overlapping of the medial and lateral femoral condyles is required. A line is drawn parallel to the inferior surface of the tibial component at the most distal level of the tibial tray (line 1). A second line is drawn at the most distal point of the femoral condyle parallel to line 1 (line 2). A third line is drawn perpendicular to line 2 (line 3). The position of the contact point is expressed in percentage: the distance between AC and PC is divided by the distance between AC and MC. AC: the most anterior point of line 1, PC: the most posterior point of line 1 and anteroposterior distance of the tibia, MC: the crossing point of lines 1 and 3.

Fig. 3. Maximum flexion was measured as the angle between the lines drawn at the midpoint of the femur and tibia.

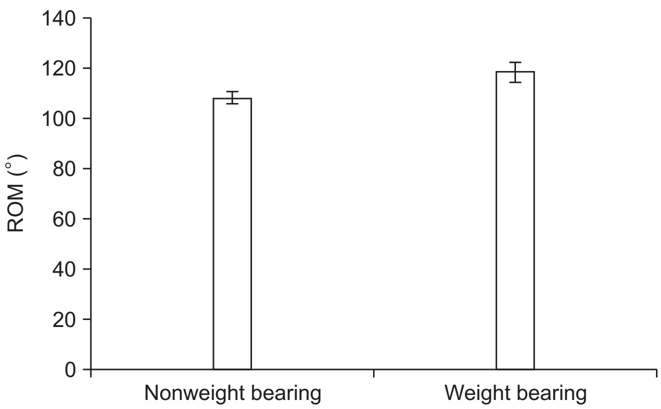

Fig. 4. Range of motion (ROM) in nonweight bearing and weight bearing conditions. ROM was increased with weight bearing (p=0).

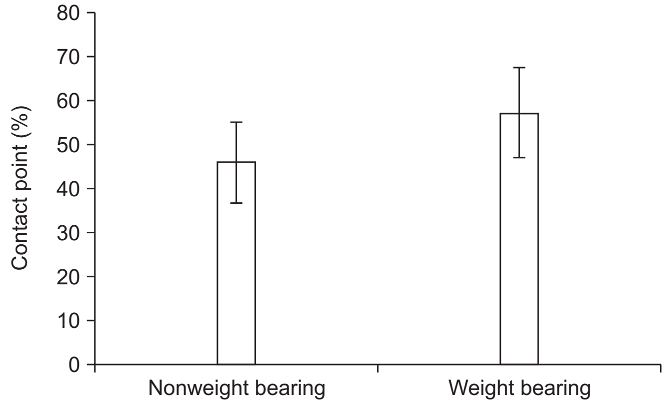

Fig. 5. Contact point in nonweight bearing and weight bearing conditions. The contact point moved posteriorly with weight bearing (p=0).

weight bearing condition were 46.1%±9.1% and 57.2%±10.2% from AP distance, respectively. The effect of weight bearing was statistically significant (p=0). The contact point moved posteriorly under weight bearing (Fig. 5).

Discussion

To measure the contact point, the method described by de Jong et al.[3] was modified to our needs. According to their method, a line parallel to the posterior tibial cortex is drawn (line 1) and a second line is drawn perpendicular to line 1 under the assumption that the tibial plate is perpendicular to the posterior tibial cortex. However, the posterior slope can vary in situations. Thus, we used a line drawn parallel to the inferior surface of the tibial component at the level of the most distal to the tibial tray instead of line 1.

The principal findings of this study include that posterior shift of the contact point in LCS-RP TKA was observed under weight bearing condition and a deeper flexion was achieved under weight bearing compared to the non-weight bearing condition. The average maximum flexion of the LCS-RP knees ranges from 94° to 114°[4-8]. However, deeper flexion and femoral rollback have been reported after fixed bearing TKA[9-14]. Greater range of motion and femoral rollback have been reported in TKA using a Sigma RP-F (DePuy), which is a mobile bearing can and post design[15]. However, these studies all evaluated flexion in a non-weight bearing condition.

The LCS-RP design increases contact surface and reduces contact stress compared to the posteior stabilized (PS) fixed bearing design. Contribution of soft tissue to the constraint in relation to the component has been increased in this design. Multi-radii nature of this design has an advantage in extension in which the contact surface increases. However, in flexion, the contact surface and constraint of the component decrease and stability of the joint relies on the soft tissue tension. This could result in instability in flexion compared to extension. In our study, anterior translation of the femoral component was observed in flexion without weight bearing, and increased maximum flexion and posterior femoral shift were observed in flexion with weight bearing (Fig. 6). The deep dish design of LCS-RP could contribute to improved congruency of the joint in weight bearing. This relationship could be evaluated in a future study.

Some previous studies showed significant correlation between AP translation of the femoral component and improved knee flexion[16,17], whereas others reported little correlation[18,19]. Ishii et al.[20] reported no correlation between soft tissue tension and AP

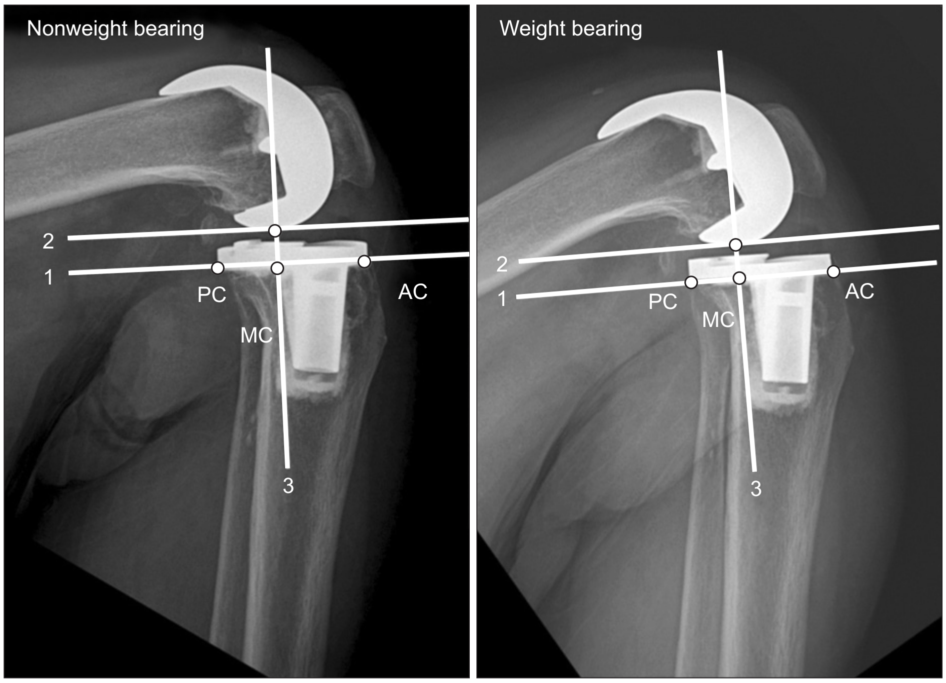

Fig. 6. Anterior shift of the femoral condyle was observed in flexion without weight bearing, and increased maximum flexion and posterior femoral shift were observed in flexion with weight bearing. PC: the most posterior point of lines 1, MC: the crossing point of line 1 and 3, AC: the most anterior point of line 1.

translation in conscious and unconscious patients. But he used AP gliding meniscal bearing without weight bearing. Weight bearing could alter soft tissue tension and posterior shift of the femoral component.

Our study has some limitations. First, the evaluation was performed using plain lateral radiographs only. Second, we analyzed the midpoints of the medial and lateral contact points. Femoral axis rotation is also important in the analysis of deep flexion of mobile bearing TKA systems. A more precise mechanism could be clarified by evaluation of contact mechanics. Third, comparison with other PS type implants in future studies is necessary. Fourth, the follow-up period was relatively short and variable; tension of the soft tissue could change over time. However, our study also has some strengths. Using simple observation, the major concept of the mechanics of deep flexion of the LCS-RP could be conceptualized although detailed research on this subject should be conducted in further studies.

Conclusions

In LCS-RP TKA, the contact point between the femoral component and the polyethylene moves posteriorly under weight-bearing condition. In addition, the knee joint becomes more congruent and the maximum flexion increases with weight bearing.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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