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Relationship between range of motion and femoral rollback in total knee arthroplasty

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Objective: The aim of this study was to evaluate the relation between femoral rollback and range of motion (ROM) in patients with cruciate retaining (CR) and posterior stabilized (PS) total knee arthroplasty (TKA).

Methods: The study included 38 knees of 31 patients (26 female and 5 male) with primary knee arthrosis who underwent TKA. The posterior cruciate ligament (PCL) was sacrificed in 24 knees in the PS group and preserved in 14 in the CR group. Mean follow-up was 30.6 months. Patients were submitted to fluoroscopic lateral evaluation for ROM and femoral rollback assessment.

Results: Average ROM of the CR group was 106.43±9° and 105.43±11.7° for the PS group ($p=0.78$). Average femoral rollback was 10.5±9.7 mm and was significantly lower in the CR group (5.8±6.5 mm) than the PS group (13.2±10.5 mm) ($p=0.026615$). While there was no correlation between the femoral rollback and ROM for CR prostheses ($p=0.78$ and $r=0.8$), there was a significant correlation for PR prostheses ($p=0.01$ and $r=0.49$) with regression pointing to an increase of 0.545 degrees ROM for each unit of femoral rollback.

Conclusion: Despite increase in femoral rollback and its relation with ROM in PS TKA, there were no differences in ROM between CR and PS TKA.

Key words: Femoral rollback; range of motion; total knee arthroplasty.

The recovery of range of motion (ROM) following total knee arthroplasty (TKA) is essential for good functional outcomes.[1] Several factors can influence ROM after a TKA, including a preoperative ROM, surgical technique, prosthetic design and postoperative rehabilitation. However, even in patients with greater preoperative ROM, loss of flexion after surgical treatment may occur.[2-11] Femoral rollback has been described as a determinant factor for the adequate postoperative recovery of the ROM.[12-14]

Controversy regarding the preservation (cruciate retaining, CR) or the sacrifice (posterior stabilized, PS) of the posterior cruciate ligament (PCL) in TKA remains. Proponents of the CR method argue that preservation allows for a normal kinematic of the knee and, consequently, protects the cement-bone interface by decreas-

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ing shear stress.[15-18] Others suggest that preservation improves ROM and quadriceps function.[19-21] Conversely, proponents of the PS method report that surfaces with more conforming articulation can be created and deformities are easier to correct, reducing the mechanical stress and polyethylene wear.[15,22]

Improvement in ROM and femoral rollback after PS TKA has been widely discussed. It is estimated that increased ROM is due to a higher rate of femoral rollback.[12-15,22] Lombardi and Berend reported that the most effective femoral rollback can be reached by sacrificing the PCL.[23]

The aim of this study was to evaluate the relationship between the rate of femoral rollback and ROM in patients made with CR and PS TKA.

Patients and methods

Details of this study were approved by the Ethical Committee of Madre Teresa Hospital and written informed consent obtained from each participant prior to the commencement of the study. No financial incentives were offered to encourage subjects to participate in the study.

In vivo knee kinematics of 31 patients (38 knees) who had undergone TKA for primary knee arthritis by the senior author (L.H.C.Jr) at Madre Teresa Hospital between 2008 and 2009 were assessed. Inclusion criteria included patients with a minimum postoperative follow-up of 24 months, Hospital for Special Surgery (HSS) knee scores of a minimum of 90 with no ligamentous laxity or pain, ability to flex the knee to at least 100° under passive conditions and those weighing no more than 120 kg and between 40 and 85 years of age at the time of surgery. Exclusion criteria included the inability to perform the required tasks without discomfort. Of the 31 patients, 26 were female (84%) and 5 male. Mean postoperative follow-up was 30.6±12.2 (range: 24 to 48) months and age at the time of surgery was 73±5 (range: 63 to 82) years. According to the Kellgren-Lawrence radiological osteoarthritis scoring system, 25 (65.8%) knees were Grade 3 and 13 Grade 4.

The NexGen® (Zimmer®, Warsaw, IN, USA) prosthesis was used in all cases. The PCL was sacrificed in 24 knees in the PS group and preserved in 14 in the CR group. Preservation of the PCL was performed when possible. Cruciate sacrifice was planned preoperatively for certain patient groups, such as, patients with inflammatory arthritis, a body mass index greater than 40 kg/m^2 or severe combined angular and flexion deformities and osteoporotic elderly females (older than 80 years).

After a minimum of 24 months follow-up period, all arthroplasties were evaluated through a lateral fluoroscopy. Maximum range of flexion, extension and femoral rollback were analyzed. The CorelDRAW® Graphics Suite X4 (Corel Corp., Ottawa, Canada) graphics process program was used to analyze the images. Images were oriented using a millimeter-gauged grid in a way to align the basis of the tibial component with the horizontal, defining the anterior point as point 0 and the posterior limit as point 100. Image extension allowed for the visualization of the point of shortest distance between the 2 components, the point of peak in extension (PE), and the definition of its position in relation to an anterior-posterior unit. The same marking was accomplished on the image in 90 degrees flexion, defining the point of shortest distance between the components as support peak in flexion (PF). The percentage of femoral rollback was defined as the division of PE by PF (Fig. 1).

Statistical analyses were carried out with the aid of Epi Info 2000 software (Centers for Disease Control and Prevention, Atlanta, GA, USA) with the level of statistical significance set at $p<0.05$. Data were tested for normality of distribution using the Shapiro-Wilk test. Mean values (±standard deviations) were compared using the Student's t-test. To determine the correlation between samples, correlation analysis was used and simple linear regression was used in the case of any significance.

Results

Average ROM for all samples was 105.81°±10.64° (range: 85° to 125°), with a mean of 106.43°±9° (range: 90° to 125°) for the CR group and 105.43°±11.7° (range: 85° to 120°) for the PS group. There was no significant difference between groups (p=0.78). Average femoral rollback was 10.5±9.7 (range: -8.6 to 27.2) mm. Femoral rollback in the CR group (mean: 5.8±6.5 mm; range: -5.6 to 18.2 mm) was significantly lower than in the PS group (mean: 13.2±10.5 mm; range: -8.3 to 27.2 mm) (p=0.026615).

There was no correlation between ROM and femoral rollback in all patients as a whole (p=0.32) and a satisfactory pattern of regression (p=0.188) was not present instantly. When analyzed separately, the construction of a model of regression was not possible for the CR prostheses (p=0.78 and r=-0.8) due to the absence of relation between femoral rollback and ROM. In the PS group, there was a significant relation between femoral rollback and ROM (p=0.01 and r=0.49). Construction of a regression model was possible in this case (regression equation: $y=98.22+0.545x$), observing an increase of 0.545 degrees on the ROM for each unit of femoral rollback.

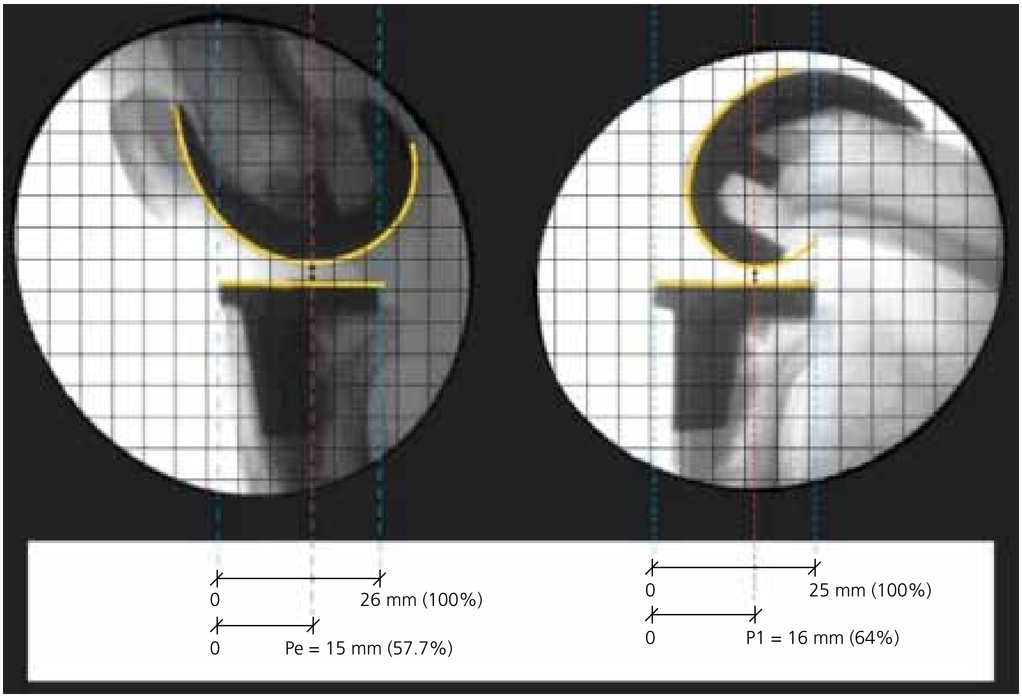

Fig. 1. Peak in extension and in flexion for the femoral rollback calculation. Pe: Peak in extension; Pf: Peak in flexion. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Discussion

Several factors can influence femoral rollback and ROM following TKA. Some factors are related to the patient's pre- and postoperative factors (previous ROM, obesity and quality of rehabilitation) and others to technical questions of the surgery (errors in the flexion and extension gaps, resection of back osteophytes, PCL preservation, elevation of the joint line, final thickness of the patella, mistakes in the positioning of the components, and changes in its design).[2-14] In order to obtain better femoral rollback without promoting instability and avoiding poor outcomes, appropriate tibial slope and resection of back osteophytes in the femur have been considered important technical factors to obtain deep flexion. Those measures contribute to a more consistent femoral rollback and avoid direct impingement of the inserts against the posterior femur.[24-26] An additional factor to observe is proper soft tissue balancing, essential for better femoral rollback.[12-15,22,24-26] In the present study, despite significant femoral rollback for PS TKA, there was no difference in ROM between groups. No relation between ROM and femoral rollback among all patients was found in the CR group, while a significant relation was observed in the PS group.

Conditt et al.[27] reported equivalent passive postoperative ROMs in CR and PS knee designs when measured by goniometer. External measurements can vary from fluoroscopy measurements by up to 9°.[28] Previous studies have reported that all TKAs have variable kinematic patterns different than those of the normal knee.[28-31] Knee implant designs that retain the PCL have been shown to display kinematic patterns closest to the normal knee.[29,30] Seon et al.[32] suggested that the preservation of the PCL would keep the femoral rollback, reproducing the normal movement of the joint and preventing a posterior translation. This would reduce the aseptic loosening and the polyethylene wear. Chaudhary et al. did not find any difference in ROM during the first postoperative 2 years between groups that underwent CR and PS TKA.[33] Kim et al. compared ROM and functional results of 250 patients who underwent bilateral TKA using 'higher flexion' PS and CR prostheses, with no difference between groups.[34] Misra et al.[35] compared groups that underwent PS and CR TKA in terms of pain relief, deformity correction, ROM, stability and strength, with no significant difference.

However, the role of the PCL in TKA kinematics is still controversial. de Carvalho Jr. et al. reported a difference in femoral rollback between PS (13.24%) and CR prostheses (5.75%).[36] Analyzing the kinematics of the components, Victor et al.[37] reported no difference between preservation and sacrifice of the PCL in the final result during a 5 years follow-up period. However, greater femoral rollback (medial and lateral) was found in PS cases with high flexion (p=0.018). While Seon et al. reported no differences in functional scores between CR and PS prostheses, mean ROM between groups were different (126.3° for PS group and 115° for CR) with femoral rollback of a mean distance of 9.6 mm during maximum flexion for the PS group and 6.1 mm for the CR group.[38] In our study, differences between ROM were not present between groups, but were found during evaluation of femoral rollback. The relation between ROM and femoral rollback was found only in PS prostheses.

The small number of analyzed knees in each group, non-randomization and the use of a unique type of implant can be considered limitations of the study. However, as this study is based on a single surgeon series, variables regarding the surgeon and surgical technique are eliminated. Future studies are still needed to better evaluate the clinical differences between CR and PS TKA.

In conclusion, despite increase in femoral rollback and its relation with ROM in PS TKA, there was no difference in ROM between CR and PS TKA.

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