Influence of Polyethylene Constraint on Tibial Component Fixation in Total Knee Arthroplasty. Follow-Up Report After 5 Years

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Abstract: The influence of articulating surface design of AMK total knee prosthesis (DePuy, Johnson & Johnson) on migration and radiographic outcome at 5 years was evaluated. The knees were randomly allocated to receive a flat or a concave insert with retention of the posterior cruciate ligament when preoperative deformity was less severe and either a concave or a posterior-stabilized insert with resection of the posterior cruciate ligament when deformity was more pronounced. In 64 knees, migration was measured with radiostereometry. The posterior-stabilized component displayed more varus-valgus tilting than the concave insert. Other statistically significant differences in migration were not seen. Radiolucent lines were frequently seen without differences between prosthesis groups. **Key words:** total knee replacement, radiostereometry, migration, radiolucent lines, joint area configuration.

Total knee replacements (TKRs) are constructed with variable amount of constraint to match the demands of stability depending on the bone and ligament status of the knee joint. By restricting motions of the knee joint, more constrained designs can be expected to transfer higher forces to the interfaces and increase the rate of migration. On the other hand, nonconstrained prostheses might be associated with remaining instability. Stiehl et al [1] studied 14 subjects with a flat on flat condylar posterior cruciate-retaining TKR during a deep knee bend and normal gait. During flexion, the medial femoral condyle slid in the anterior direction, and the lateral condyle was acting as a pivot. Condylar lift-off was seen predominantly on the lateral side. This phenomenon will concentrate the load on only one condyle and cause peripheral edge loading, which will increase the demands of the fixation [2].

Szivek et al [3] tested 7 TKR systems to determine contact stress patterns and contact areas using calibrated Fuji film. Conformed tibiofemoral designs demonstrated the largest contact areas and lowest contact stresses suggesting less wear and a positive influence on the fixation.

We aimed to evaluate the influence of tibial insert design on migration of the tibial component and the development of radiolucent lines in AMK TKR. In previous reports of these studies after 2 years of follow-up, Uvehammer et al [4,5] could not verify their hypothesis that the tibial components with least inherent stability would be associated with less migration. We now report our findings after 5 years of observation.

Patients and Methods

Eighty-three patients (87 knees) with noninflammatory gonarthrosis were operated with the

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AMK (DePuy, Johnson & Johnson) total knee replacement. Patients with a 5° or less varus-valgus alignment were randomly selected to receive either a relatively flat or a concave tibial plateau. The posterior cruciate ligament (PCL) was retained. Patients who had more than 5° varus-valgus alignment and /or extension defect of 10° or more were randomly selected to receive either a concave or a posterior-stabilized (PS) tibial component. The PCL was resected. The alignment was measured in radiographs as hip-knee ankle [6] To reduce the risk of randomly occurring differences in demographics, the patients were stratified using a minimization method [4,5,7]. Four patients underwent bilateral TKR. None of them received the same implant on both sides. At 5 years, there were adequate radiostereometry (RSA) measurements in 16 patients in each group. Six surgeons with at least 7 years of surgical experience operated the patients.

Lost to Follow-Up and Revisions

Fifteen patients were lost to the 5-year follow-up. Two patients were revised before the 1-year follow-up [4]. After 2-year follow-up, one patient with a flat insert was operated with intramedullary nail because of supracondylar femoral fracture and had 25° of valgus alignment after nailing. Seven patients had died because of reasons unrelated to the TKA, one had dementia, three patients refused follow-up because of other disabilities, and one had moved abroad.

Radiostereometry

Eight to 9 spherical tantalum markers (size 0.8 mm) were inserted into the proximal tibia after preparation of the bone and before cementing of the components. Three 0.5-mm and three 0.8-mm tantalum markers were inserted in the polyethylene component. The biplanar radiostereometric technique and the UmRSA 3.2 software (RSA Biomedical Innovations, Umeå, Sweden) were used. Fictive points were used to measure translations [8]. Rotation around the transverse, longitudinal and sagittal axes, maximum subsidence, maximum lift-off, and maximum total point motion (MTPM) represented migration of the tibial component. Maximum total point motion denotes the length of the translation vector belonging to that point of measurement, which moved the most. Radiostereometric examinations were done 4 to 7 days, 3 months, and 1, 2, and 5 years after the operation. Radiostereometric study of 7 knees was excluded because of poor marker configuration, loss of tantalum markers, or poor visualization of markers. In one knee, too few markers were visualized on the postoperative view. In this knee with flat insert, the migration between 3 months and 5 years is presented separately. Radiostereometric studies between the postoperative and the 5-year follow-up could be accurately evaluated in 64 knees.

Precise RSA measurements are dependent on well-scattered and stable markers. The scattering of the tantalum markers is expressed as the condition number [9]. Smaller values indicate better scattering. Values less than 110 were accepted in the present study.

The mean condition number of the tibial bone markers was 26 (range, 14-79) and that of the tibial insert markers 37 (range, 19-103).

The mean error of rigid body fitting reflects the stability of individual markers within each segment [9]. High values indicate marker instability. In the present study, the limit for acceptance was set at 0.35. The mean error of the tibial bone and the mean error of the insert markers were 0.23 mm (range, 0.05-0.34 mm) and 0.21 mm (range, 0.09-0.34 mm).

At the beginning of this study, measurements of RSA radiographs were done manually. Some examinations at 2 years and all the 5 years of follow-up were measured digitally, which improves the precision [10]. Previous studies of the precision using manual measurements with our set-up have shown detection limits (95% confidence limits) of 0.16 mm for subsidence and 0.2° to 0.4° for rotation depending on the direction [11].

Radiographic Evaluation

Radiolucent lines around the tibial and femoral components were evaluated according to the Knee Society scoring postoperatively and after 2 and 5 years [12]. An orthopedic surgeon, who had not operated on any of the patients, evaluated the radiographs. The width of all zones around the tibial and femoral components is summarized resulting in a total score for each component. Radiolucent with a total score of 5 to 9 should be followed for progression and 10 or more signifies possible or impending failure. The hip-knee ankle angles in these knees at 2-year follow-up have previously been presented [4,5].

Clinical Evaluation

The Hospital for Special Surgery Knee Scores (HSS) [13] was used at the clinical evaluation.